THE PLANTING, CULTIVATION, AND EXPRESSION

OF

COCONUTS, KERNELS, CACAO,

AND

EDIBLE VEGETABLE OILS AND SEEDS OF COMMERCE.

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COCONUTS, KERNELS, CACAO

AND EDIBLE VEGETABLE OILS AND SEEDS OF COMMERCE.

A Practical Handbook

FOR PLANTERS, FINANCIERS, SCIENTISTS, AND OTHERS

BY

H. OSMAN NEWLAND, F.R.Hist.S., F.L.D., &c.

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INTRODUCTION

FEW people realise how important to us and to the world at large are the products of the oil-yielding trees and plants contained within the Empire. The Germans, although they had wisely accumulated large reserves of the vegetable fats and oils mostly from our own and their lost African empire have recently suffered through lack of these precious stuffs, while the British official statement during the war that glycerine was no longer to be supplied to chemists, showed clearly how want of foresight added to the difficulties of the war on our part

We have in our vast tropical possessions an enormous variety of raw materials which can be exploited with little trouble, and will produce lavish supplies of fats and oil to satisfy our hungry population, and also give the glycerine necessary for the manufacture of high explosives.

Soft palm oil, for instance, contains glycerides from which 9 to 10 per cent of glycerine can be obtained by up-to-date machinery and methods We have in our Empire vast quantities of this raw material

Before the war the Germans practically controlled and worked up the bulk of the oils and fats from West Africa and in nearly all our tropical possessions, and margarine and nut butter were largely imported to Britain from abroad. These products, now made in Britain, have

tended more and more to replace dairy-butter, which, although far dearer than before the war, is no more nourishing and frequently less palatable. Careful analyses show that the vegetable fats and oils from kernels and copra have a higher nutritive value than most butters, especially those imported. Yet there is still a prejudice against "margarine," which it is desirable to remove.

More important still, is the necessity for arousing our Government, capitalists, and public alike to the vast and scarcely tapped wealth of our tropical colonies in foodstuffs and other valuable commodities of the Empire. Especially, perhaps, is it desirable to attract attention to West Africa. In its wealth of vegetable oils and fatty substances, West Africa stands out prominently as an important region of the earth's surface. Only about 5 per cent. of its wealth in vegetable oils has been tapped, and although this great commerce has been barely a hundred years in existence, it had already contributed trade to the amount of over fifty million pounds per annum to the world's markets before they were disorganised by the war. Yet, as Sir Harry Johnston has pointed out in criticising the constitution of the Commission appointed by the Government to inquire into the oil yielding plants of West Africa, "not a single trained botanist appeared amongst its members."

Even to-day, our Government scarcely realises the value of West Africa, and there is a section which would willingly make over all Togoland and the Cameroons to France, or perhaps hand them back to Germany, and would stand by while the independent republic of Liberia is annexed or exchanged, or would internationalise all Tropical Africa.

Germany, however, has always realised the importance of Tropical Africa, and the dream of a *Mittel-Afrika* is not yet abandoned. The importance to her of tropical oilseeds alone may be gauged from the fact that on the averages of the years 1912 and 1913 Germany imported the following: 218,000 tons of palm kernels, 109,000 tons copra (the dried fleshy part of coconuts), 445,000 tons linseed and linseed meal, 217,000 tons cotton seed, 125,000 tons soya beans, and 81,000 tons peanuts (earthnuts). Considerable quantities of these, especially of palm kernels, are now diverted to this country, and it is of the greatest importance that the British farmer should become familiar with the by-products produced from them.

What is known in the trade as the "hardening" process will doubtless, in the future, bring into competition with the principal oils mentioned in this book, many liquid and even low fish oils for soap-making and edible purposes. There will always be a market for the superior oils, but only at a price, and one which may penalise the economic position of the Colonies.

Before the war also the bulk of our own palm-kernel trade in West Africa went to Germany.

In 1913 over 234,000 tons of palm kernels were exported from British West Africa, of which over 181,000 tons went to Germany and about 40,000 tons to this country; and in 1912 over 50,000 tons of the same were exported from French West Africa, of which about 43,000 tons went to Germany and about 3,500 tons to this country.

Perhaps we were partly to blame for this state of things. For example, at Hamburg, according to evidence given to the Edible Nuts Committee, the cost of landing

palm kernels was 8d per ton, and at Liverpool 7s. 3d. Thus, the English importer started with a handicap of 2s 7d. Another witness put it at 3s 9d. At Hull there are no quay charges, and, as a consequence, large oil crushing mills have been started there. Other reasons are stated in the chapter on Palm Oil and Kernels.

However, as a result of the aforesaid Committee's inquiries, an export duty of £2 per ton has been recommended, although it is not regarded with favour by the natives or their journals on the Coast.

The result of this export duty of £2 a ton, equal to £4 a ton on the oil, should be: (1) Germany should pay the duty of £2 a ton to our West African possessions on the kernels she requires for her own consumption. (2) British manufacturers should make and sell to Holland the oil for their margarine trade instead of the kernels, as that country has no duty on the oil. (3) In Great Britain we should have the power to crush what we require for ourselves and do an export trade to Canada, the United States, the River Plate, and many smaller markets.

One of the large Dutch margarine makers has already given out contracts for the construction of a very large factory indeed on the lower reaches of the Thames, to be rapidly pushed forward as soon as building operations are possible, and it is almost certain that when one large producer finds it to his interest to manufacture here his competitors will follow.

Another result of the publication of the Report of the Colonial Office Committee has been a desire on the part of the public for further knowledge concerning oil-seeds and oil-nuts.

I have, therefore, been prevailed upon to issue as a separate book the chapters on "Ground Nuts," "Palm Oil and Kernels," "Cacao" and "Shea Nuts," which originally formed part of a volume on *West Africa* in preparation for publication after the War and, while enlarging the same, to add chapters on Coconuts and other edible oil-nuts found throughout the Empire. Special reference is made to planting, cultivation, and expression.

I am indebted to the publishers of my "Sierra Leone, Its People, Products and Secret Societies," for permission to quote from that volume and for the illustration of a Cacao tree; also to *The Producer*, the organ of the Co-operative Wholesale Society, for extracts from my articles to that paper, the publishers of my *West Africa*, for the chapters mentioned, and to the Belgian Government, Messrs. Cadbury, Lever Bros., Craig & Co., and the Eastern Palm Estates, Ltd., for some of the photographs.

H. O. NEWLAND,
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AUTHORS' CLUB,
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THE Author desires to record his indebtedness to the *Bulletin* and other publications of the Imperial Institute, and to express his regret that a suitable acknowledgment was accidentally omitted from the text.

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THE COCONUT AND ITS USES.

CHAPTER I.

THE COCONUT AND ITS USES.

THE coconut is perhaps the most popular and best known of all the valuable oil-bearing plants; but although so well known, it is only quite recently that its value in making butter and other edible fats was discovered. Perhaps it was due to the Right Hon. Lord Leverhulme that the boom in this commodity, which has not yet reached its zenith, was first foreshadowed, if not begun. That great soap magnate and philanthropist recorded his opinion that "there is no field of tropical agriculture so promising, and no industry in the whole world offering so lucrative an investment of time and money as that of coconut cultivation." Every year about ten thousand million coconuts are cultivated, besides the vast numbers which grow wild.

In 1914 the value of the world's exports of copra and coir fibre (two products of the coconut) was estimated to be nearly 50 per cent. greater than the value of the world's output in rubber, and only 40 per cent. less than the world's output of gold; and companies, whose speciality is coconut butter, have paid as much as 200 per cent. dividend. Hence the coconut deserves a first place in a book of this character. Further, unlike many oil-bearing trees, it is found on most of the islands and coastal regions of the tropics up to 20° or 25° north and south of the Equator. Its greatest successes have been achieved in New Guinea, Malay, Sumatra, Panama, Java, the Philippines, Ceylon

the West Indies, the Malabar Coast, British Guiana, and it is now being cultivated in India and East Africa. The coconut is an important commercial product for exploitation in West Africa, but it requires careful handling; for, although coconuts are found all along the coast, they are not in any one area so numerous as to make by themselves a good paying proposition. In most cases—excepting here and there in a part of Sierra Leone, in Togoland, or in Liberia—they are scattered and under the control of different families or tribes, and only those who know the country and its laws and have obtained the confidence of the people can successfully combine various lands and planted areas for commercial working.

Only since the author * drew attention to the possibilities of coconuts in the Sierra Leone Littoral has the Government seriously taken up coconut growing there, importing the seeds from Malay. Previously the authorities had failed, owing, among other causes, to native antipathy, the natives neglecting to water the young trees because "the nuts themselves contained liquid."

Similarly, about seven years ago the Agricultural Department of the Gold Coast Government reported that the natives were making extensive plantations of coconuts, and that many were giving the trees very careful attention and taking a greater interest in the preparation of copra. These developments are now commencing to yield their beneficial results. Up to 1905 the coconut had not been energetically cultivated in West Africa, but copra is now commanding such abnormally high prices that there is every inducement to stimulate the industry. After the war immense developments will take place;

* "Sierra Leone: Its People, Products, and Secret Societies."

soil, climate, etc., are so favourable that the palms flourish naturally, and could be brought to a higher level of productivity by scientific, up-to-date methods; native labour is abundant and cheap; land is available at moderate rates; West Africa is much nearer the principal European markets than most other coconut-growing regions, consequently freightage is cheaper, the copra arrives in a better condition, and commands a higher price; the coast is outside the hurricane zone, and thus escapes the destructive storms from which those within the hurricane zone so frequently suffer.

During the four years previous to 1916 an average of over half a million nuts per year had been exported from Dominica, and as the local consumption is considerable, over one million nuts are probably produced annually (*Rep., Agric. Dept., Dominica*, 1915-16, p. 13). In the Lassoye district about 500 acres were planted with coconuts during the years 1913-14 to 1915-16. In British Guiana the area under coconuts continues to increase, and there were in 1916 over 18,000 acres under this crop compared with 5,140 acres in 1914. Over 80 tons of copra and 3,000,000 nuts were exported in 1916 from this colony.

Coconuts produced on several plantations on the coast and adjacent islands of Nicaragua have long been noted for their size, fine flavour, and good keeping qualities. An American enterprise has now acquired the plantations, extending for 32 miles along the coast below Monkey Point, between the Indian and Corn rivers.

The soil best suited to the coconut palm is a deep and fertile sandy loam, such as is found in alluvial flats along the sea coast at the mouths of rivers, or in wide

river valleys. It is in such situations and on such soils that the coconut palm is most commonly found to flourish, but it can be grown inland, especially by the banks of a tidal river, the ebb and flow causing ideal conditions. The principal products derived from the coconut palm are:—Coconuts, copra (the dried kernel of the nut from which coconut oil is expressed), desiccated coconut (prepared from the fresh kernel, and largely used for confectionery purposes), and coir fibre, which is prepared from the husk of the fruit.

In tropical countries where the coconut palm is grown, nearly every part of the tree is utilised by the natives. The roots are used as an astringent in native medicine, and are sometimes chewed as a substitute for betel or areca nuts, sometimes interwoven with fibres to form baskets. The trunk, which, when mature, develops a very hard outer shell, is used to form rafters and pillars of native buildings. The inner portion of the trunk is too soft to be of value as timber, but the outer portion is capable of taking a fine polish, and is sometimes used in this country in marquetry work and cabinet-making. From its peculiar markings, consisting of ebony-like streaks or short lines irregularly disposed over a reddish-brown ground, it is known as "porcupine wood." The leaf-bud or "cabbage" is much appreciated as a vegetable or salad by both natives and Europeans, but to obtain it, or to tap the palm for wine the tree has to be sacrificed. (Planters need, therefore, to keep a sharp look out.) The fully grown leaves are put to numerous uses; they are formed into mats, baskets, roof-coverings for native huts (ataps or codjans), fences, articles of clothing, and ornaments. The petioles or leaf-stalks are

used to make fences and handles for tools, and when cut into short lengths and frayed at the ends they serve as brushes. The midribs of the leaflets furnish a strong fibre that is used for making baskets, strainers, and native fishing tackle. The sheaths produced at the leaf-bases consist of triangular pieces of fibrous material having a woven appearance; these are cut into various shapes to form mats.

The flower spathes, when dried, are used as torches, and are also twisted into coarse ropes after being soaked in water.

The water contained in the unripe nut is a cool, refreshing drink that is much appreciated in tropical countries, and constitutes the only available drinking water on some of the smaller oceanic islands, while the soft, creamy kernel of the unripe nut, when flavoured by spices and lime-juice, is eaten as a delicacy.

The ripe nuts enter into the composition of numerous native sweetmeats and curries. Coconut milk is prepared by grating the fresh kernel and mixing it with a little water and then pressing through a cotton cloth. The liquid which passes through the cloth is an emulsion consisting of oil suspended in water with a little mucilage and sugar. It resembles milk in appearance and consistency, and is extensively used in India in the preparation of curries and as a substitute for cow's milk.

The oil obtained from the kernel of the nut by boiling with water, or by expression, is used as an article of food, and also employed for culinary purposes. The husk is utilised as fuel, and sections are used as brushes; the fibre of which it is largely composed is made into brushes, yarn, cordage, and matting. The coconut shells are used

as fuel, and are also formed into drinking vessels and numerous other articles of domestic use, as well as being carved and polished for ornaments. The author has seen Kru boys on the West African steamers using the natural husk, cut into pieces, as a scrubber.

"Toddy" is obtained from the coconut inflorescence before the flowers expand. The natives climb the tree and bind the flower spathe in several places with strips of palm leaf to prevent it expanding. The spathe is then bruised by a club or mallet. The beating is periodically repeated for ten or twenty days, a portion of the spathe is cut off, and from the wound a quantity of liquid exudes, which is collected in a vessel. This "bleeding" continues for about a month, each day a fresh slice being removed from the spathe to facilitate the flow of the liquid. Six pints a day is sometimes obtained from a single tree. In a fresh state this liquid forms a sweet and pleasant beverage, and is drunk by both natives and Europeans. After standing for a short time it becomes a highly intoxicating beverage known as "palm wine." If allowed to remain for a few weeks, palm wine becomes converted into vinegar. In a state of fermentation toddy is sometimes used in bread-making as a substitute for yeast.

Desiccated coconut is now in considerable demand in the confectionery industry, both for itself and as a substitute for almonds. The United Kingdom, Germany, the United States of America, Belgium, France, and Austria import this product, which consists of the fresh kernel stripped or shredded and dried in ovens. Desiccated coconut will keep sweet for a long time, but its preparation is confined to those countries where large

supplies of *fresh* coconuts are available, as only fresh kernels can be used.

The hard shell is removed by a hatchet, or preferably by a small power-driven circular saw, if such is available. The outer brown skin of the kernel is then shaved off by a spokeshave, or, if possible, a steam-driven revolving rasp. Halving the shaved kernels, the moisture is drained away, and another machine strips or shreds them. The nuts must be dried immediately or the oil in the kernel will become rancid. Three average-sized nuts produce one pound avoirdupois of desiccated coconut.

A little sugar or starch may be mixed with the shredded kernel to aid the drying process. Too much sugar, however, renders the product crisp and easily breakable; too much starch makes it pasty and gives it a greenish tint. Ten per cent. of sugar or 5 per cent. of starch is the maximum permissible. Two methods of drying are:—

(1) Spread the shredded kernel on polished iron tables heated by steam from below. Stir the material frequently, and let the vapour be driven through chimneys in the roof.

(2) Dry on trays in a drying room heated to 110° F. Stir frequently, and, when quite dry, remove from the heated chamber and allow to cool. Pack in lead-lined chests and seal for export.

Coir is a fibre from the husk or mesocarp of the coconut. Its fineness depends partly upon the situation of the plantation, partly upon the time at which the nuts are gathered. Palms growing near the sea produce finer fibre than those growing inland. Nuts should also be collected before ripening, as the fibre becomes coarser

as the fruit matures. To prepare the fibre, the natives remove the husks by hulling, and place them in basket-work cages in backwaters or pits containing brackish water, where they remain for many months to soften. Then the fibre is freed from the non-fibrous matter, dried, cleaned, sorted, and baled for export.

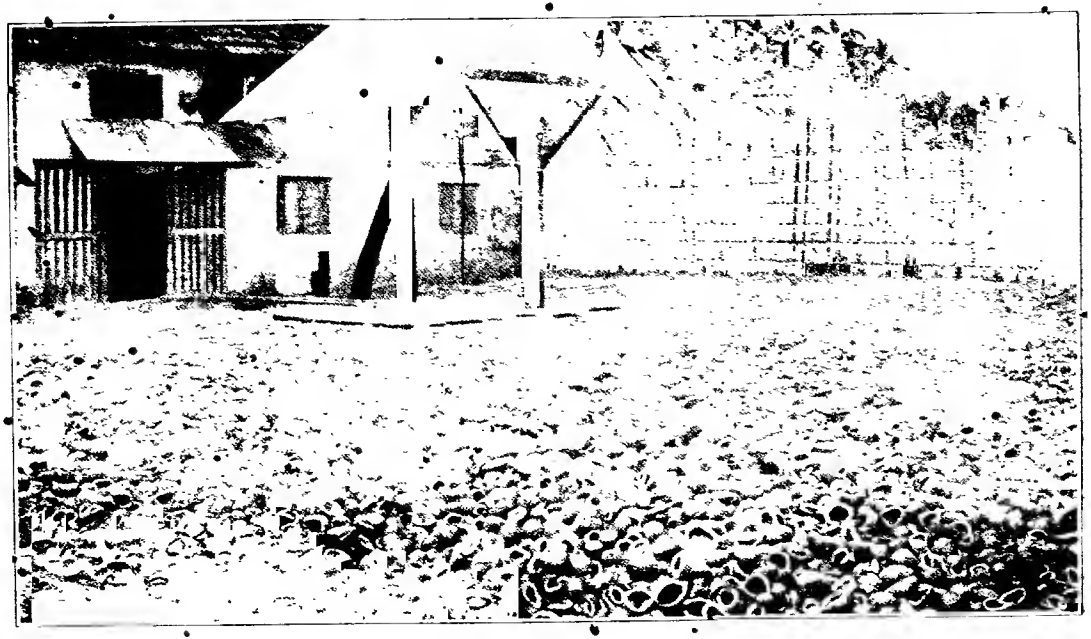
In sorting, "fibre" consists of the finer fibres used for spinning purposes and for mats or ropes; "brush" fibre is coarser and stiffer, and is employed in the manufacture of brushes and brooms. Short "curled" fibre or tow is used in upholstery as a substitute for horse-hair, and the dust or refuse for bulbs and garden purposes. Twelve thousand coconut husks yield one ton of coir fibre.

Copra is the matured kernel of the coconut broken into pieces and well dried, either in the sun, or, more frequently now, perhaps, by mechanical means in hot-air evaporators, where the shell does not fall away at the time when the nuts are broken.

The high value of copra is due to the oil it contains. To extract the oil the early method was first to pound the copra into a meal and then to cast this meal into a vat of boiling water, whereupon the oil, released by the heat and rising to the top of the water, was recovered from the surface by skimming; but to-day oil is "expressed" from the copra, the entire process being performed by machinery. The copra is properly milled, the resultant meal being steamed and fashioned into large square cakes; and from these cakes, upon submitting them to a hydraulic pressure of several tons per square inch, the coveted oil is "expressed," or squeezed.

The reason why the public hears little of the "coconut

PLATE I



Drying Copra

oil" and much of the "copra" market is because, while only a few big firms provide themselves with the machinery necessary for the manufacture of oil, the majority ship their produce in the form of copra—the raw material—and, therefore, while copra interests and is handled by thousands upon thousands of planters and dealers at home and in almost every tropical region known, the oil may be said to concern, comparatively, a very limited number of refiners and manufacturers.

One coconut of average size yields nearly 5½ ozs. of oil, besides 3 ozs. of dried oil meal.

And now, a few words about the planting of coconut estates, and the yield and profits accruing therefrom.

In planting out an estate, seed should be taken from well-matured trees of from 25 to 30 years of age, showing a good yield; and large-sized roundish nuts, either red, brown, or green, but *not oblong nuts*, should be selected. The seed nut must either be picked from the tree in completely dry condition, or, better still, gathered up when fallen.

Gathering the nuts green, and then drying them in a room, is to be avoided, as trees grown from such nuts do not mature well, and generally decay, whereas nuts having become completely dry when on the tree can be planted any time from one to twelve months after collection.

The seed nut must not have too much or too little milk. It should be half-full. After shaking several nuts, it is easy to estimate the amount contained in them. Nuts containing too much milk will easily rot; those with none will soon perish. The nuts are planted in a nursery in trenches, and are transplanted to required

positions within two to eighteen months from the time shoots make their appearance. The seed beds are carefully prepared and well heaped up, but not made so wide as to interfere with watering them in dry weather. The nut should not be planted too deep, nor covered with more than 1½ to 2 inches of earth. Manuring is not necessary, as it only attracts ants and beetles. The beds must be kept clean and the soil loose, to get rid of grubs.

A month or two later shoots appear, and the plants are ready for transplanting at the end of one year, when they should have an average height of 18 inches. The seed beds must be kept moist and the young plants watered during a continuance of dry weather. Care is taken to remove the plant with the decaying kernel still attached to it, but the roots are sometimes cut rather short to prevent rot.

All leaves, except the inmost ones, are cut to diminish resistance to the winds. Transplanting from the nursery, the planter digs channels or trenches alongside the plants, slightly deeper than the bottom of the roots, previously well watering them to prevent the earth crumbling from the roots during removal, the idea being to retain with it as much of its natural soil as possible.

The seedling is lifted carefully from the nursery beds, and any damaged roots cut back. A small hole is made in the centre of the large one, and in this the nut which is still attached to the young plant is placed, and covered for about three parts of its depth. The soil is not levelled at the time of planting, but a basin-shaped depression is formed round the young plant. As growth progresses this will become filled with fine sandy soil washed in

by the rains, or it may subsequently be made level by means of a top-dressing of light, rich soil.

Another system is to transplant the seedlings from the seed-beds to a piece of good land that has been well dug and manured, planting from 3 to 6 feet apart, according to the length of time it is intended they should remain. The plants should be kept well watered and free from weeds and pests. When two and a half or three years old they are lifted and transplanted to their permanent positions. This system admits of a selection of the best seedlings from the seed-bed for transplanting to the nursery, and of a further selection for forming the permanent plantation upon which the trees should be planted out, 30 by 30.

Watering is essential to a coconut plantation, and only light catch crops should be grown in between the trees (*e.g.*, sweet potatoes, cotton, pine-apples, and pulses). About the fourth or fifth year these crops should be abandoned, and cattle tethered to the trees to graze.

A series of manurial experiments with coconuts in Trinidad and Tobago indicated that only in one instance was the increase in yield sufficient to compensate for the cost of treatment, the notable exception being on the King's Bay Estate, where the application of a mixture of 2 lbs. of dissolved bone and 1 lb. of sulphate of potash per tree has given a steady yearly increase.

The entire coconut fruit is not often seen in Europe. Ovoid in shape, it is covered by a waterproof epidermis or outer skin, attached to the inside of which is a thick fibrous cushion known as the husk, and the well-known nut is embedded within this husk in much the same manner that a peach stone is embedded within the flesh

of that fruit. The coconut kernel, unlike other kernels, is practically hollow, and the hollow or cavity is almost completely filled with liquid, generally termed coconut "milk," the walls of the kernel at this stage consisting of a white pulp or jelly barely one-quarter of an inch thick; but as the coconut gradually matures so is the "milk" for the most part absorbed and used in the building up of the pulp or jelly-like walls, until at full age these walls are sometimes three-quarters of an inch thick.

The average yield when the trees are in full bearing varies from fifty to seventy nuts per tree, if good cultivation and manuring have been practised. Individual trees have been known to yield from 150 to 200 nuts annually.

The nuts are produced in bunches of from 10 to 12 nuts each. Natives climb the trees and throw down the nuts. One native should harvest 400 nuts a day, and he should at the same time remove dead leaves from the crown and search for beetles or other insect pests. In a few places the nuts are allowed to remain until they fall naturally from the trees, especially if such nuts are required for seed purposes.

The cost of forming and maintaining a coconut plantation varies according to (*a*) rent, (*b*) the character and condition of the soil, and (*c*) the supply and cost of labour. The following is a fair estimate for the Malay States:—

First Year.—Felling £750, draining £750, seed £350, fencing £200, lining and planting £150, coolie lines £65, bungalow £150, tools £35, stationery £15, medical £200, weeding first six months at £20 per acre, superintendence £500, contingencies £150, say . . .	£3,000
Second Year.—Weeding £750, superintendence £500, medical and contingencies £250, ...	1,500

Third Year.—Weeding, £750, superintendence, £500, medical and contingencies, £250, ... £1,500
Fourth Year.—Weeding only £450, ... 1,200
Fifth Year.—Weeding only £400, ... 1,150
Sixth Year.—Weeding only £450, picking £40, curing £150, transport £150, ... 1,500
Seventh Year.—With extra cost picking, ... 1,900
Eighth Year.— „ „ 2,200

It is assumed that the production of copra will be on the average of 220 nuts to the picul of copra (133⅓ lbs.), the average yield per tree of five years of age in Malay and Ceylon being 1½ lbs.

In East Africa palm lands vary from about 4s. to £1 per acre; clearing and weeding during the period before trees arrive at the producing stage is estimated at £2 per acre. Full bearing takes place at the tenth or twelfth year; and an annual yield of three-quarters of a ton of copra to the acre has been obtained.

The following is an estimate of revenue, expenditure and profit from 2,000 acres of virgin land in West Africa Capital outlay, £20,000 :—

	Gross Profit.	Upkeep.	Net Profit.
Eighth year, . .	£12,280	£2,600	£9,680
Ninth year, .	18,800	3,500	15,300
Tenth year, . . .	27,320	4,300	23,020
Eleventh year, . .	36,080	5,500	30,580

The above estimate is based on copra at £21 per ton and coir fibre at £10 per ton, thus leaving a very large margin on present values.

Another authority gives the following figures of the

revenue, expenditure, and profit from *copra alone* from 500 acres in Malabar. Capital outlay, £4,000 :—

	Gross Profit	Expenditure.	Profit.
Sixth year, 20 nuts per tree,	£11,200	£2,800	£8,400
Seventh year, 40 ,,	28,000	7,000	21,000
Eighth year, 60 ,,	39,200	9,800	29,400

Valuation has always been taken as seven years' purchase of the estimated profits, and a fair investment valuation may be taken as ten years' purchase of estimated profits, as there is not the same fluctuation in the price of copra as there has been in rubber.

In some parts of the world coconut estates are many but small, and in different hands. The question of co-operative milling has, therefore, arisen. In this connection it may be said that it is estimated a minimum of 7,200 tons of copra per year, or 14,000 acres of coconuts in bearing, would be required to justify the erection of a co-operative mill. After 8 per cent. had been set aside for interest to shareholders and fair depreciation allowed on machinery, the profit accruing would be divided amongst the contributing estates according to the quantity of copra delivered.

PALM OIL AND KERNELS.

CHAPTER II.

PALM OIL AND KERNELS.

First, perhaps, in commercial importance, among the oil products of West Africa, is that of the oil palm; there is an enormous supply of this commodity in the country which at present rots on the ground, and which might be turned to profitable account by very shrewd enterprise, working on more economical lines than the majority of present plantation companies in West Africa.

The oil palm,* which is indigenous to West Africa, from Senegal and Bissagos on the north to the Congo Basin and Angola on the south, is most prolific from Sierra Leone to the Cameroons from the seaboard towards the interior, diminishing in those districts where the climate becomes drier, or where rocky and mountainous tracts intervene. It is rarely found beyond 200 miles from the coast. The most suitable situation is where the soil is generally moist. Swampy, ill-drained land is not favourable. In those parts of the country where there is gravelly laterite over a deep substratum of syenite, trees may abound in considerable numbers, but the trunks of such trees do not acquire the same thickness as those growing in damper or lighter ground. No distinct varieties are recognised by the natives, although distinctive names are applied to the same fruit in different stages of development. Yet there is great disparity between oil palms, both in yield and quality, to the extent of 30 per cent. Some have thin pericarps,

* See "Sierra Leone: Its People, Products, and Secret Societies."

yielding less oil and more kernels—*e.g.*, in Sierra Leone—others have thin-shelled kernels and thicker pericarps. The oil palm does not thrive in heavy forest, but in open valleys with low undergrowth. The seeds or nuts, which are large and heavy, are distributed by the agency of birds and mammals.

The full-grown oil palm attains a height of about 60 feet, and consists of a stem covered throughout its length with the bases of dead leaves, and bearing at the apex a crown of large, pinnate leaves, each of which may be 15 feet long, with leaflets 2 feet or 3 feet long.

The tree is very slow growing, reaching a height of 6 inches to 9 inches in three years, 12 inches to 18 inches in four or five years, 8 feet in ten years, 13 feet to 14 feet in fifteen years, and attaining its full height of 60 feet in about 120 years.

The fruit is borne in bunches termed "heads," "hands," or "cones," which are small and numerous when the tree first begins to bear, from the fourth to the eighth year, and larger but less numerous as the tree becomes older. The oil palm requires little cultivation; wherever natives settle in previously uncultivated spots, they plant oil palms, and, as they rarely cut these down when subsequently clearing their fallow ground, the number of such trees increases from year to year.

Where, however, the oil palm has received the attention of the plantation, as in French Guinea (and in the Krobo district of the Gold Coast before the cocoa boom set in), the palm groves are in a more flourishing condition, and have yielded better results. The cocoa trees in the Krobo district were first planted as catch-crops

PLATE II.

Natives climbing Oil Palms in West Africa.

between the palms, but, proving more lucrative, have become the main crop.

In French Dahomey every encouragement is being given by the Government to the oil palm industry among the natives, and the result has been to make this one of the most flourishing of the African colonies which France possesses on that continent.

In Nigeria, the British Government has encouraged more careful planting of palms, with the result that oil from these districts fetches the best price. In Liberia, a British syndicate is interesting itself to produce good results.

On a plantation, the distance between palms should be not less than 25 feet, and catch-crops should not be grown after the tenth year.

Permanent crops such as cocoa and rubber are hardly suitable for interplanting with the oil palm unless the palm trees are at least 45 feet apart, when funtumia elastica and cocoa may be grown satisfactorily. A rotation of crops may be carried out where the palm trees are 25 feet apart with the following products:—Maize, manihot (cassava), ginger, ground nuts, tobacco, chillies, yams, native beans, and pine-apples. But before planting a large area of any one product the demand of local and European markets should be carefully studied. It is worthy of note, too, that local markets in West Africa are to-day worth attention, good prices being often realised for maize, cassava, ginger, native beans, and yams. The returns from the sale of the catch-crop produce should help to pay for the necessary attention required by the permanent crops until they come into bearing, as well as to meet other working expenses of the estate.

Each tree from about 10 to 30 feet in height is calculated to bear at least seven cones of fruit, and in full bearing under good conditions the yield is from 8 to 10 bunches.* A record bunch has weighed 56 lbs. and contained 1,445 serviceable oil nuts. The yield per acre would be from 536 to 670 bunches from the eighth year, where palm trees are planted 25 feet apart, which gives 67 trees to the acre. The yield of oil per acre by European method of extraction would be from one to one-and-a-half tons of oil, exclusive of kernels. The quantity of kernels obtainable per tree would vary from 26 to 35 lbs. according to the variety, or from 15 to 21 cwts. per acre.

The natives remove a few of the lower leaves around the crown of the tree each year. This practice is supposed to increase the yield from 25 to 50 per cent., and is worth trial by Europeans.

To secure the cones, the natives have become expert climbers. The cones are cut with sharp knives, in order to detach the fruit. This fruit consists of (*a*) an outer covering or pericarp, which contains the palm oil of commerce, and (*b*) the palm nut. The pericarp often holds about 60 per cent. of its own weight of oil, and as this part is 40 per cent. of the whole, the amount of oil is about 24 per cent. The fruit, when freed from the cone, is placed in the sun for a few days and fermented

* According to Adam (*Le Palmier à huile*, pp. 118-121), an average yield of about 10 fruit heads, each weighing 13·2 lbs., and equivalent to 85 lbs. of fruit per tree per annum, may be counted on in districts favourable to the oil palm, such as Lower Dahomey. Farquhar (*The Oil Palm and its Varieties*, p. 20) says that an average of five bunches is obtainable in favourable districts in Nigeria, each bunch weighing 31 lbs., but that the bunches are smaller in the dry zone and in dense forest. There is no doubt that the yields of fruit vary considerably in different localities.

PLATE III

West African native bringing the palm fruit into store (illustrating

by being stacked in heaps and covered by leaves for some days more. The release of the fruit from its fibrous case is thereby easier. In consequence of the fermentation, the glycerine (now worth £200 per ton), of which the palm oil, when produced from fresh fruit, contains as much as 10 per cent., is reduced to 5 or even a lower percentage, making, as may be imagined, a very serious difference in its market value.

The Germans were keen on introducing European methods of improvement. At the Agu plantation in Togoland, for example, the process employed there extracted the best palm oil obtainable, containing only 5 to 6 per cent. of fatty acid. And only as late as July 4th, 1914, Direktor Hupfield, of Togoland, told the Third International Congress of Tropical Agriculture that increase in exportation might be attained by (1) an extension of the districts capable of exporting by improvements in the means of transport; (2) a more intensive utilisation of the existing palms through better methods of cultivation; (3) a better utilisation of the crops obtained through improved methods of preparation; (4) an increase in the existing number of palms by increased activity of the present producers or the introduction of fresh producers; and (5) methods of preparing the crop by machinery which have been elaborated within the last decade.

Both British and French are now taking up the matter more seriously, and several British firms, notably Lever Bros. and the Co-operative Wholesale Society, have taken up large concessions under European management.

Several important organised efforts have now been made to supplant the wasteful native method for re-

covering the yellow oil from the pericarp, by establishing modern plants within the area in which the oil palm flourishes. These modern plants offer one of the most favourable opportunities for the investment of capital, as the native labourer will soon find that the collection of fruit for these establishments is easier and more profitable than attempting to extract the oil himself. At the same time, users of palm oil in Europe will be furnished with a product which, on account of the large proportion of glycerine it contains and better average condition, will be of greater value than the variable and uncertain product that is now shipped by the West African native.

The cost of extraction by the native methods is from £10 to £12 a ton. Half that estimate should cover the cost by machinery under European management.

The problem of the mechanical extraction of palm oil has been approached from two standpoints—(1) the construction of small, cheap, portable machines capable of being worked by hand and of being transported from place to place as required; (2) the erection of central factories dealing with large quantities of palm fruit by means of heavy, power-driven machines.

At least two hand-operated machines, very similar in principle, have been patented for the preparation of palm oil, in both of which the palm fruits are placed in a cylinder with hot water and submitted to the action of beaters, the oil and water being afterwards run off through a grid or sieve. The "Gwira" machine patented by Eglen (*English Pat.* 3357/1909) has been experimented with on the Gold Coast. The other machine, in which the palm fruit is beaten in hot water for extrac-

tion of the oil, is that of Phillips, a native of Lagos; an early model of this machine was patented in 1907 (*English Pat.* 9733), and an improved form in 1912 (*English Pat.* 18370). It consists of a smooth cylinder mounted inside a cylindrical casing and around a shaft bearing beaters. The outer cylinder carries a water tank with a valve to control the flow of water, while the inner cylinder carries on the lower side a sliding sieve to separate the oil and water from the nuts and fibrous waste; this arrangement of the sieve allows its removal so that the exhausted material can be discharged through a space in the inner cylinder. This machine was exhibited at the International Rubber and Tropical Products Exhibition held in London in 1914, and according to the advertisements issued at that time, it cost £5. Although little is known with regard to the efficiency of oil extraction by this machine, it should prove useful in economising time and labour in the preparation of palm oil on a small scale by natives.

The first power-driven machinery for cracking palm nuts is believed to have been introduced into West Africa in 1877 by Mr. C. A. Moore, of Liverpool, and was devised by Messrs. Mather & Platt, Ltd., of Salford. Hand machines were introduced about 15 or 20 years later.

In 1901 a prize offered by the Kolonial Wirtschaftlichen Kommittee of the German Kolonialgesellschaft (*Verhand. Kol. Wirt. Kom.*, 1909, No. 1, p. 54) was awarded for a complete set of small machines constructed by the firm of F. Haake in Berlin and designed to extract palm oil from the fruit and also to crack the nuts and liberate the kernels. Plant made by this firm was

exhibited in 1909 in Berlin, and afterwards erected at Mamfe on the Cross River (Cameroons). Similar plant was also erected at Victoria in the Cameroons, and at about the same time a French firm erected a plant of French make at Cotonou in Dahomey. These early factories were all on a small scale, working about 5 tons of palm fruit per day.

Subsequent power machinery falls into two classes—(1) those in which the whole fruit is pressed without removal of the nuts, and (2) those in which the fruit pulp is removed from the nuts and pressed alone.

Noteworthy among the former are (*a*) the machines devised by Poisson and constructed by Louis Labarre, of Marseilles: (*b*) the mill devised by Hupfeld and constructed by Messrs. Humboldt, of Cologne; (*c*) the machine patented by Hawkins.

The most prominent of the second class was, before the war, that of Haake, of Berlin. Other machines have been patented by Buchanan and Tyrell, and by Dyer and Innes-Ward.

Complete plant for the preparation of palm oil in which the pulp is removed from the nuts and then pressed is made by A. F. Craig & Co., Ltd., Paisley, Scotland; A. Olier et Cie., Argenteuil, France; and Louis Labarre, Marseilles. The plant constructed by the first-mentioned firm is known as the Caledonia dry plant, and differs in method of working from most of the existing processes in not steaming or boiling the fruit or pulp with water before expression of oil. It is claimed for this process that neither the fruit nor the oil comes in contact with water, so that even if fatty acid and glycerine occur in over-ripe fruit no glycerine is lost. The process of

depericarping is effected by a machine patented by H. G. Fairfax (*English Pat.* 18050/1914).

The oil, after being boiled, yields a pleasant and yellow-coloured fat, which is sometimes eaten and relished by Europeans residing in West Africa. Most of it, however, is exported to Europe and used for various purposes by the soap-maker and the chandler, not to speak of war purposes. Some oil is harder than others, notably that from thin pericarps; the softer oil is of two qualities, (*a*) Lagos and (*b*) ordinary soft oil, both of these oils fetching from £3 to £4 per ton more than the harder quality.

Soap-makers and other users of palm oil are now demanding a contract for their requirements, based on purity and on the first grade of oil containing not more than 18 per cent. of free fatty acids. Many of the inferior grades will thus become unmarketable, except at a seriously depreciated price.

The softer the oil and the more glycerine therein (which varies in inverse proportion with the acidity) the greator its value.

The chemical and physical constants of the palm oil of commerce are :—

Specific gravity at $\frac{15^\circ\ C}{15}$, ...	0·9209 to 0·9245
Melting point, ...	24° to 42·5° C.
Saponification value, ...	196·3 to 205·5
Iodine value, ...	53 to 57·4
Reichert-Meissl value, ...	0·86 to 1·87
Hehner value, ...	94·2 to 97

Solidifying point of fatty acids varies from 35·8° to 46·4° C., usually 44·5° to 45·0° C.

The kernels or seeds contained in the nuts or "stones" of the oil palm are obtained by cracking the nuts by hand or by the aid of a nut-cracking machine, after the orange-

coloured palm oil has been extracted from the outer pulpy portion of the fruit. In Sierra Leone, this is, principally, the work of thousands of small farmers in the Colony and Hinterland, who, with wives and families, work at this industry during the season. Their produce is collected by agents and sub-agents representing the large trading firms.

The kernels are exported, and the expression of the kernel oil carried out in Europe. Palm kernel oil is white in colour and of rather softer consistence than palm oil. The kernel, when it reaches the mills, is treated either by the crushing or chemical extraction processes to obtain this oil. The oil forms about 50 per cent. of its contents, and has a very high commercial value, being sold at about £40 per ton in peace time, and at a much higher figure during war. Formerly employed solely in the manufacture of soap, candles, etc., palm kernel oil has latterly been more and more in demand among the makers of edible products, such as "nut-butter," chocolate fats, etc. Before the great World War, most of our supplies of this oil were imported from the Continent. Now that the question of the people's food supplies has become one of vital moment to the country, the production of large quantities of wholesome nut-butter, sold at almost one-third the price of ordinary butter, and manufactured entirely within our own borders from produce supplied by British Colonies, may be regarded as a factor of no small importance in furthering the national policy by facilitating domestic economy.

Before the war the Germans imported kernels from Liverpool, and then sent the oil back to that port and undersold the Liverpool crushers.

PLATE IV.

The Native Preparation of Palm Oil in the Congo.

This was done by Germany putting a heavy tariff of £6 a ton on refined edible oils, importing the palm kernels free, and charging her own manufacturers and countries with whom she had special treaties, an extra price which enabled her to undersell the British market. She also captured the Canadian market, although Liverpool enjoyed exceptionally low freight to Canada. Before the war, also, Britain imported margarine to the extent of 1,518,297 cwts. in 1913, value £3,917,701. Of this amount 1,483,417 cwts. came from Holland. Now Britain is making her own margarine from her own raw material, and as it was being bought retail at from 7d. to 1s. per lb., while butter was costing 2s. to 2s. 6d., the gain to the consumer at home is great.

Messrs. Lever now have their own steamers running between West Africa and Liverpool for their trade in kernels and oil. In Sierra Leone alone, the palm kernels exported in 1917 reached the record figure of 58,000 tons.

The following table gives the range of the principal constants of commercial palm kernel oil. The corresponding figures for coconut oil are added for comparison :—

	Commercial Palm Kernel Oil.	Coconut Oil.
Specific gravity 99°/15°,	0·873	0·874
Iodine value, per cent.,	10·3 to 17·5	8·0 to 10·0
Saponification value,	242 to 256	246 to 268
Titer test,	20·0° C. to 25·5° C.	21·2° C. to 25·5° C.
Hehner value,	91·1	82·4 to 90·5
Reichert-Meissl value,	5·0 to 6·8	6·6 to 7·5
Polenske value,	..	18·0
Yield of oil,	46·7 to 52·5	64·5 to 74·7

When the weight of a cask of palm oil is ascertained,

and in invoicing the same to the buyer in this country, 16 lbs. per cwt., or one-seventh of the whole, is deducted as representing the weight of the cask.

This is an agreed figure and applies only to such casks as are termed "regular," and comply with a certain measurement. In the case of palm kernels, if these are shipped in bags, the actual weight of the bags is ascertained by trial, and this weight is deducted from the gross weight of the kernels. The usual tare is 13 lbs. for five bags; when shipped in bulk there is no tare.

An ingenious and simple nut-cracking machine has been devised recently by J. O. Drews. It consists of a pair of finely corrugated steel jaws, one of which is fixed vertically to the frame of the machine, while the other is moved by means of a specially constructed cam. The moving jaw has its corrugated face formed at a slight angle to the face of the fixed jaw; the space between the jaws is, therefore, wider at the top than at the bottom, so that larger nuts dropped between the jaws lodge near the top and small nuts near the bottom. In working, the moving jaw takes up three consecutive positions: (1) discharging, fully open, allowing the broken nuts to fall through; (2) feeding, partly closed; (3) cracking, a small auxiliary cam mounted on the main cam engages with the operating rod of the moving jaw, causing the latter to take a short, sharp movement and to crack the nut-shells without breaking up the kernels. The nuts are fed to the jaws by means of a sloping tray ending in a series of ⌋-shaped bars mounted at right angles to and above the faces of the jaws. A series of ⌋-shaped bars mounted on a shaft rotate between the bars on the feed tray, pick up a row of nuts, and throw

them between the jaws. The machine is light, simple, and strong, and seems to work well.

The working of another new palm-nut-cracking machine devised by Mr. Kent Johnston has been demonstrated recently in Liverpool. This machine works on the centrifugal plan, but differs from other centrifugal machines in that the nuts are flung from one ribbed rotating disc or drum into or against another disc rotating in the opposite direction. The machine is said to work satisfactorily, and weighs 130 lbs., being of convenient size for transport.

Every such effort to get the most out of kernels will probably be welcomed by merchant and native alike, especially as soap-makers and margarine-makers, and other users of kernel oil are calling for a contract in which kernels will be valued according to their oil contents, anything containing less than 48 per cent. of oil to be penalised.

Palm-kernel cake is the residue from the kernels of the nuts of the West African oil palm after expression of the oil.* More than one-quarter million tons of nuts have been for the past few years annually exported from West Africa, but until the outbreak of the war, and the consequent closing of the German ports, this huge trade was almost entirely in German hands. A small quantity of the nuts was imported into Britain, but almost all the cake left from the extraction of these was exported to the Continent, where it has always commanded a considerably higher price than in this country.

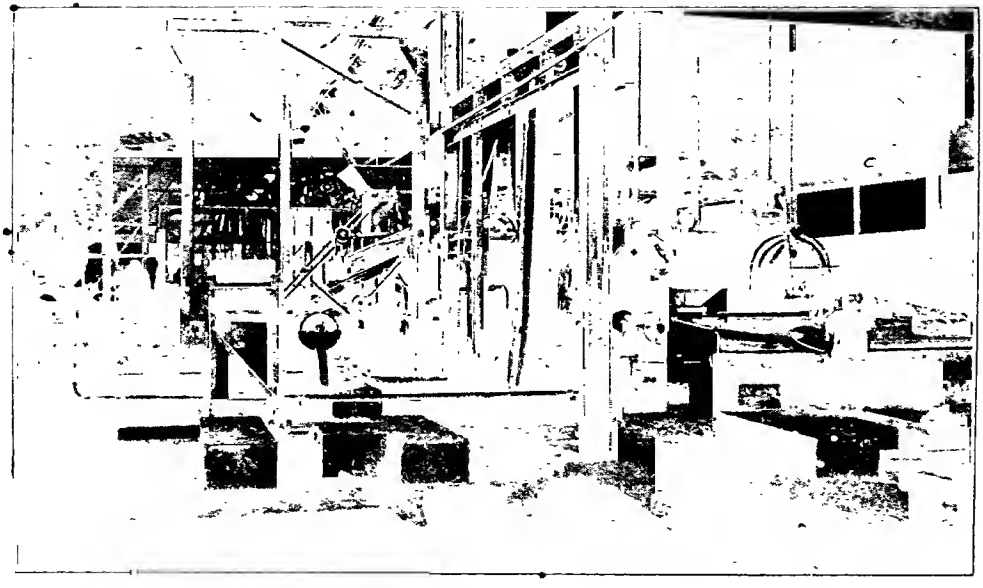
* "Expression" is the more correct term when the material is crushed in a press and the oil squeezed out, "extraction" when oil is dissolved by suitable solvents (*e.g.*, benzine). Solvent extracted oils are now used extensively for edible purposes.

As far back as 1861, at the Royal Agricultural College, Cirencester, it was experimentally established that kernel cake was good stuff for cattle, but the Germans discovered that palm kernel cake given to milking cows would increase the amount of butter fat by as much as over ½ per cent., so that by giving it to their cattle they were able to get as much butter from nine cows as before it took ten cows to produce. For that reason throughout the German Empire for many years palm kernel cake has been more valuable than it has been in England.

At the end of 1914 there were only two mills in Britain dealing with palm kernels, and their combined capacity amounted to only 70,000 tons per annum. Since then, however, a considerable development in this industry has taken place, and new mills (*e.g.*, at London and Hull) have been erected capable of dealing with large quantities, so that, in the near future, very large stocks of palm-kernel cake will be at the disposal of the home feeder.

For the purposes of experiment, 2 tons of the cake were supplied by Messrs. Lever Brothers, Port Sunlight, who, in connection with their industry, crush a considerable quantity of palm kernels. These experiments have shown that palm-kernel cake is very highly digestible, and that its productive value is much higher than its chemical analysis alone would lead us to believe. For this reason three cakes were used in equal quantities throughout the experiment. For the purposes of the experiment, thirty head of cattle, eighteen heifers, and twelve bullocks, all cross-bred two-year-olds, were used. These were divided into three lots of ten each—each lot consisting of six heifers and four bullocks. For

PLATE V



Up-to-date Modern Machinery for dealing with Palm Oil and Kernels at La Société des Huileries du Congo

short time before the commencement of the experiment they underwent a preparatory period of feeding, in order to accustom them to the experimental foods—Lot I. getting linseed cake, Lot II. decorticated cotton cake, and Lot III. palm-kernel cake. The cakes were fed in mixture with locust-bean meal, and were from the first taken readily by all the animals. The experimental period, which extended to eighty-four days, was divided into three periods of twenty-eight days each, the animals being weighed at the commencement, and again at the end of each period. The final conclusions reached were :—

"I. Fed in the same quantities, palm-kernel cake may be expected to give equally as good a return in live weight increase as linseed cake or decorticated cotton cake, and at present prices it gives a better monetary return than either of these.

"II. Fed in mixture with locust-bean meal, it is taken readily by stock, and no difficulty need be experienced in storing cake containing a comparatively large percentage of oil."

The County of Northumberland Education Committee has issued a very valuable report on palm-kernel cake and meal, and coconut cake compared with Soya cake for fattening cattle and sheep. The trials were carried out at the County Agricultural Experiment Station, Cockle Park. The summary results were :—

	Standard Ration.	Palm Kernel Cake Ration	Palm Kernel Meal Ration.	Coconut Cake Ration.
	Lbs.	Lbs.	Lbs.	Lbs.
Bullocks,	16·50	12·44	14·19	15·70
Heifers,	8·92	10·00	9·25	7·42
Average,	12·71	11·22	11·72	11·56

The cakes and meal were kept in the granary and were in quite good condition after being stored for some months.

In some previous trials palm-kernel cake gave the cattle more glossy coats and more "bloom," but in these trials no such effect was produced on the fattening cattle or on the young stirks.

Better average gains were given by those wintered inside than those wintered outside, but at the end of March practical valuers attached 30s. a head more value to those wintered outside, as they had better coats of hair and were more promising grazing cattle. Palm-kernel meal gave better results than palm-kernel cake with these young cattle, although the meal contained less than 2 per cent. of oil and the cake nearly 6 per cent. The gains per week were quite satisfactory for such store cattle in winter, and each lot went through the winter well.

The sheep used were three parts bred hogs and had been bred near Rothbury in 1915. All the lots made satisfactory gains, which indicated palm-kernel cake and palm-kernel meal as suitable foods for fattening sheep. Again palm-kernel meal gave a better result than palm-kernel cake.

The fattening bullocks made average net gains of from £3 to £6 a head. Their live weight value increased from 47s. to 62s. a cwt. during the fattening period. The fattening heifers made average net gains of 50s. to 64s. a head. The net gains per head for the stirks varied from 10s. to 23s., and their value as stores increased from 42s. 6d. a cwt. at the beginning of the winter to 48s. at the end. The fattening hogs made net gains per head

of from 3s. to 5s., and improved in live weight value from 5½d. to 6¼d. a lb. during the fattening period.

Palm-kernel meal is found to be an excellent basis for a pig meal, and as more oil is obtained from palm kernels by means of the extraction process of which palm-kernel meal is the by-product, it was also of the greatest importance to test extracted palm-kernel meal as a feeding-stuff.

The following table gives the composition of palm-kernel cake in comparison with coconut, linseed, and cotton-seed cakes :—

	Constituents per cent					
	Soya Cake	Egypt Cotton Cake	Coconut Cake	Palm-Nut Cake.	Palm-Kernel Meal.	Maize.
Moisture,	10·40	11·60	11·65	11·00	12·40	14·30
Oil,	6·03	4·07	8·37	5·40	1·35	4·54
Albuminoids,	43·85	24·30	21·75	21·00	18·81	9·89
Carbo-hydrates,	29·97	34·33	41·96	43·12	40·94	68·20
Fibre,	4·60	20·15	10·75	15·78	22·60	1·47
Ash,	5·15	5·55	5·52	3·70	3·90	1·00
	100·00	100·00	100·00	100·00	100·00	100·00
Nitrogen,	7·02	3·89	3·48	3·36	3·01	1·58
Sand,	0·65	0·70	1·05	0·75	0·80	none
Digestible oil,	5·5	3·8	8·1	5·2	1·3	4·0
Digestible true albuminoids,	37·7	19·9	16·5	17·5	15·6	6·7
Digestible carbo-hydrates and fibre,	21·6	28·6	41·5	46·1	49·4	65·4
Starch equivalent,	67	47	80	75	66	82

Another product of the oil palm which is not so generally known is fibre; this fibre is of very good quality, and realises as much as £60 a ton on the Liverpool market.

It is the only fibre that is sufficiently fine and strong

to make fishing lines, and this is the only use to which it is put by the natives. It is obtained from the young pinnæ, the older leaves being too strong and coarse to permit the hand-extraction of the fibre.

The process of extraction is laborious, and, therefore, unremunerative, the cost of the production being as high as £75 a ton. There remains, however, a possibility that a mechanical or a chemical process may be introduced to separate the fibre from the pinnæ cheaply.

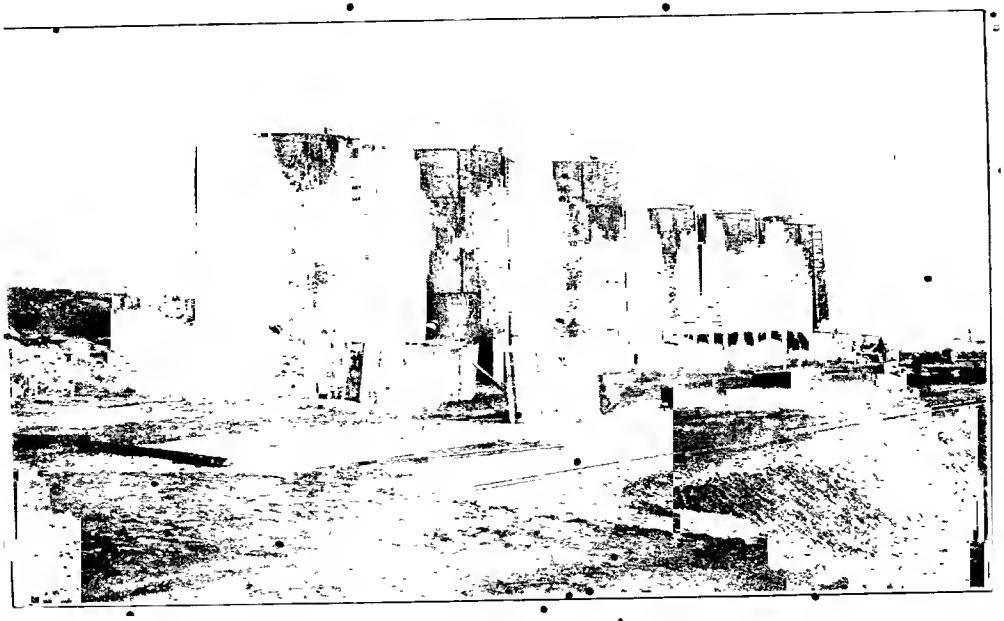
The tendency in the palm oil and kernel trade is to have large factories and mills on the spot for treating the material, and, therefore, a few words are necessary on this subject. First, the selection of a site for an oil-palm factory necessitates a careful examination of the productivity of oil palms in the vicinity.

Secondly, factories requiring large supplies of palm fruit near at hand will probably have to resort to plantation methods, in which case the choice of the best variety of palm for planting will be essential.

Thirdly, a factory requiring 5 tons of palm fruit daily and producing from about ½ to 1 ton of palm oil, will require about 30,000 trees (say 80 to the acre). This is based upon the calculation that, as the fruit heads consist of only 64 per cent. of fruit (the remainder being useless fibrous stem, bracts, etc.), it would be necessary to collect and transport to the factory nearly 8 tons of fruit heads daily, or, taking the number of working days in the year as 200, and thus allowing for the fact that the palms do not bear fully throughout the year, over 2,500 tons per annum.

Smart (*Committee on Edible and Oil-producing Nuts and Seeds, Minutes of Evidence*, 1916) states that an area

PLATE VI.



Tanks for Commercial Supremacy at Palm Oil at Kinshata, Congo

of 14 square miles (about 9,000 acres) would be desirable for the establishment of a factory working 10,000 tons of fruit a year, but that such an area in full bearing would produce over 25,000 tons of fruit a year, or 1,000 tons of fruit per annum from 360 acres, which agrees closely with the figure arrived at above. It is obvious that large factories would require considerable areas even under plantation conditions, but that under the present conditions, where the trees are largely wild and irregularly distributed and where it is necessary to allow for bad seasons, the loss of fruit owing to animal and human depredations and other eventualities, a much larger area would be required. From the above considerations it is evident that even a moderate-sized factory must be located in the centre of a large oil-palm area, and that considerable quantities of fruit must be collected and transported over long distances, necessitating a good supply of cheap labour and adequate transport facilities.

Finally, one word about the packing and transport. Care should be taken that kernels do not cause a fire on board ship. In Nigeria six sacks of palm kernels were submitted by the police department for investigation as to the cause of a fire which occurred in the hold of a ship loading in the Lagoon. The fire seems to have broken out in several separate places in the cargo, which consisted of bags of kernels solidly packed.

The kernels had been stored some time in the bags and it was the dry season. There had been a blazing sun and little breeze for several days previously during the period of loading, and so not only was the fibre of the sacking made very dry, but also it would have become

more oily from the heated kernels exuding oil and there was very little chance of the heat being reduced in a closed full hold. Such oily fibre would absorb oxygen from the air very readily, and in these circumstances the temperature would rise so high as to cause oily vapours to inflame and so start the fires. The sacks showed that the fires started at the outside fibre, and not inside among the kernels, and after the fire the fibre of the sacks held from 20 to 25 per cent. of oil.

THE GROUND-NUT.

CHAPTER III.

THE GROUND-NUT.

THE high price of butter in this country is leading now to the establishment of a new industry in Great Britain—*i.e.*, the crushing of monkey-nut or ground-nut kernels for the extraction of a pale yellow oil, which is of great value in the manufacture of margarine, for which, with butter at so high a price, there is an increased demand. Ground-nut oil is also used for preserving sardines and as a lubricant and illuminator. Inquiries are being made at the leading seed-crushing centres for the establishment of this new branch of the oil-extracting industry, and a movement has also been started to erect mills in Scotland to forward the industry. The kernel of the monkey-nut contains about 50 per cent. of oil, which belongs to the non-drying class of oils, of which up to 40 per cent. can be extracted by crushing machinery. As India, Egypt, the West Coast Protectorates, both British and French, East and Central Africa, Rhodesia, etc., are able to supply large quantities of these monkey-nuts, there is every promise of the development of a large export trade in the commodity. The annual exports from India and West Africa alone amount to about £5,000,000; and in the United States, every large town has its "pea-nut" factory. Our French Allies pay great attention to the crushing of monkey-nuts, and extensive crushing businesses are established at

Marseilles, and they will probably do their utmost to encourage the Colonial industry.

Other countries which express this oil are China, Java, the United States, and Japan.

The ground-nut, earth-nut, monkey-nut, or pea-nut, as different nuts of the same species are variously called, is the fruit of a yellow-flowered herbaceous plant belonging to the *Nat. Ord. Leguminosæ*, which is cultivated extensively in Gambia, Senegal, Hong Kong, India, Nigeria, East Africa, and the United States. The value of the nut largely depends on its oil content, which in a good sample will average 40 per cent. of the seed by weight after extraction. At the same time, the leaves and branches of the plant form an excellent fodder for cattle and sheep, and should always be utilised after harvest.

The flowers are peculiar and worthy of consideration, as they have a considerable bearing on the successful cultivation of the crop. After fertilisation the torus or seed stalk of the flower becomes elongated, rigid, and, deflexed, and forces itself into the ground where the ovary at its extremity begins to enlarge and develop into a yellow wrinkled one to three-seeded pod. If the ground be so hard as to prevent the seed stalk from burying the developing ovary, the whole part withers and no fruit is formed, hence the necessity for keeping the soil in a friable condition until the flowers be set.

The highest percentage of marketable nuts is produced in sandy loams; soils deficient in lime, if rich in nitrogen, will produce luxuriant plants but little fruit, and clay soils are always unsuitable, producing small pods of low quality.

In ordinary field conditions, the soil should not be

cultivated to a greater depth than 6 inches, but the tilth must be thorough; deep cultivation adds considerably to the cost of harvesting.

If the soil be carefully selected, little after-cultivation is necessary; three hoeings before the crop covers the ground are generally sufficient.

The plants should be so close as to completely cover the ground when full grown, and protect the soil and roots from direct sun; 15 inches by 15 inches is a suitable distance.

The quantity of shelled seed required per acre depends on the system of planting, but 30 to 35 lbs. per acre is ample with a planting distance of 15 inches by 15 inches.

The proportion of shell to kernels varies, some varieties of nuts give 66 per cent. kernel and 34 per cent. shell, and others up to 80 per cent. kernel and 20 per cent. only of shell. A good ground nut should give, apparently, 48 per cent. to 50 per cent. of oil in the kernels. The following table of yields of dried nuts per acre is given by the *Imperial Institute Bulletin*:—

Crop	1910	1911.
	Lbs.	Lbs.
Carolina running,	1,706	2,438
,, ,, (selected),	1,548	..
Gambia,	1,479	2,041
Gambia (three-seeded),	1,254	2,027
Local variety,	1,670	1,789
Red Tennessee,	765	1,846
Virginia running,	..	1,836

The sandy plains in Bida or Kano in Northern Nigeria, according to its able Director of Agriculture, offer an ideal soil for ground-nut production. A yield of over a ton of freshly harvested nuts per acre was being

generally obtained at Kano, and at Bida at least 1,400 lbs. of kernels per acre were obtained in the 1912-13 season. A superior variety of ground-nut is grown in the neighbourhood of Pategi, Ilorin Province, which might be useful to draw upon for seed elsewhere.

In the Gold Coast Colony, where the Hongkong as well as the native variety is cultivated, at least in some of the centres, crows and rodents seem able at times to secure more than their fair share of the crop, in spite of its being underground.

In Gambia, ground-nuts—which form by far the most important article of cultivation in that colony—alternated with the staple food crops of the country—viz., guinea corn, maize, millet, and cassava, offer a fairly useful form of rotation.

At the beginning of each season, "strango farmers" appear in Gambia, and take up the cultivation of the ground-nut area, doing planting and harvesting on a percentage system, so much going to the owner of the land. After harvesting and selling, the strange farmer disappoars with his good profit, and may not perhaps be seen again. There is never, however, any dearth of such farmers.

Harvesting the crop is by far the most expensive operation, and no system yet devised can do away with the large amount of hand labour necessary for gathering the crop. In Nyassaland it is dug and gathered in a manner very similar to that employed for the Irish potato crop.

After harvesting, the nuts are usually sun-dried for about a week, and not shelled until required for shipment, but machines can now be secured to dry the nuts artificially.

Under ordinary field conditions 4 acres to the ton of shelled nuts would be an average for Nyassaland, and the following figures, taken from a 6½-acre block grown at Namiwawa on unmanured land in 1915, show the cost of production and value of the crop, the figures being based on actual working expenses :—

Cost of Production per Acre and Value of Crop

	s	d
One ploughing,	2	8
One cultivation,	0	8
One harrowing,	0	4
Three hand hoeings at 7½d.,	1	10½
Harvesting and shelling,	12	8
	18	2½

The total crop from 6½ acres was 7,318 lbs. of unshelled nuts, which on shelling gave 4,024 lbs. of sound shelled nuts, or a yield of 619 lbs. of exportable kernels per acre, and at £13 10s.* per ton represents a value per acre of £3 14s. 6d.

Experiments in the East Africa Protectorate with two varieties of ground-nuts, Chinese and Shirati, gave yields of 2,700 lbs. and 2,600 lbs. of nuts (in shell) per acre respectively. In the latter case the crop was only sown as a catch crop, and was planted too far apart for profitable cultivation.

The ground-nut, being less sensitive to climatic variations than cotton and much freer from disease, is worthy of the attention of the larger land companies, who could, if interested, encourage their tenants by distributing selected seed and guaranteeing to purchase the crop

* Average price on home market 1914. The price during 1917-18 rose to £70 to £90 a ton

at one halfpenny per pound after deducting the weight of the seed issued.

The nut contains 50 per cent. of fat, 24·5 per cent. of protein, and 11·7 per cent. of carbohydrates, these being the principal nutrient components of vegetable foods. It makes an excellent substitute for peas and beans, possessing several preponderant advantages.

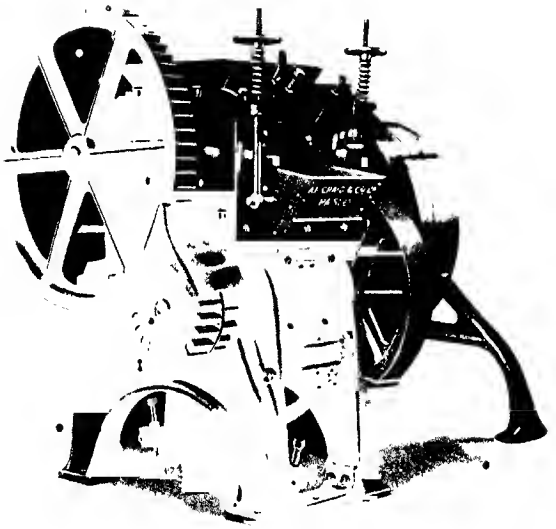
In Nigeria a nutritious and appetising soup is made from the nut. In the United States, where the pea-nut is extensively used, its value is already being recognised. It is said to fatten more rapidly than any other diet, and if eaten regularly in moderation, to be capable of sustaining life indefinitely. An excellent bread and biscuit may be made from the nut, in the making of the latter no lard being required. It may also be used as a beverage, either alone, when it resembles chocolate in flavour, or mixed with pure coffee, when it is better than many of the coffee mixtures now on the market. The oil of the nut is highly esteemed, being regarded as an alternative to sweet or olive oil.

Small quantities of selected grown nuts have been used in England in confectionery as a substitute for almonds. In India they are extensively eaten roasted, and are now made into sweetmeats, being mixed with palmyra, palm, or sugar-cane jaggery.

By far the greater part of the world's production of ground-nuts is, however, used for the expression of oil, and for many years Marseilles has been the great centre for the ground-nut trade for oil.

Oil is prepared in West Africa by means of crude native wedge presses, or pestle and mortar mills; such oil is, however, only employed for local use. An ad-

PLATE VII.



"Craig" Reducing Mill for Copra, Palm Kernels, etc.

vantage of local extraction is that oil can be prepared from nuts in a fresh condition, freight charges are lessened, and the residual cake becomes available for local use.

A short description of the machinery and processes for more scientific extraction of the oil may here be desirable

In preparing ground-nut oil, the outer husk is generally removed, although oil can be expressed from unshelled nuts. Where native women and children are available this labour can be done by hand, but small hand machines are obtainable and more effective. Such machines break the husks between rollers set at such distance as to prevent the crushing of the kernels in the process; the husks and as much as possible of the red "skin" of the kernel being removed by a blast of air. The husks can be blown to the engine and used as fuel, or, mixed with meal, they may be made into cakes.

The cleaned kernels are ground between rollers, then placed in hydraulic presses. The first pressing takes place at ordinary temperature, yielding as much as 30 per cent. of pale-coloured oil. This "cold-drawn" oil is known as "huilo surfine" de Rufisque, Gambia etc., according to the origin of the nuts. This is used for edible purposes. A further 6 or 8 per cent. of oil inferior in quality, but still useful for edible purposes can be obtained by moistening and warming the cake in steam kettles at a temperature of 30° to 32° C. An additional 5 to 7 per cent. of oil, unfit for edible use, but very good for soap, can be obtained by a third expression at a temperature of from 48° to 50° C. The second and third expressions are usually made in open Anglo-American presses, which employ bags or cloths to hold the cake.

The following are approximate yields obtained from different kinds of ground nuts :-

Kind	From Undecorticated Nuts	From Decorticated Nuts.
	Per cent	Per cent
Rufisque,	31·5	45 to 46
Gambia,	31	..
Egypt,	31·5	..
Mozambique,	..	42 to 45
Bombay,	..	37 to 38
Coromandel,	..	36 to 37

The last three kinds are shipped decorticated, and consequently undergo changes rendering the taste indifferent and the cake inferior. The cake left after the expression of the oil is a valuable feeding stuff for cattle and other animals.

The following analyses of various feeding cakes are stated below :-

	Ground-nut Cake		Cotton-seed Cake		Linseed Cake.	Soya Bean Cake.
	Decorticated.	Undecorticated	Decorticated	Undecorticated		
	Per cent.	Per cent	Per cent.	Per cent	Per cent	Per cent.
Moisture,	10·6	11·6	9·00	13·75	11·16	12·7
Ash,	5·95	5·70	7·10	4·60	5·20	5·05
Oil,	7·73	7·17	11·38	6·56	9·50	11·07
Protein,	49·31	28·50	43·78	24·62	29·50	38·82
Carbohydrates,	21·71	28·06	23·56	29·28	35·54	26·51
Crude fibre,	4·70	18·97	5·18	21·19	9·10	5·85

In Senegal, where, with one set of six decorticating machines worked either by a locomotive or a portable engine, 5 tons of nuts in the shell were decorticated per hour, with the result that out of 280 tons treated 199 tons

of kernels were obtained. This was so satisfactory tha extensive plant is to be erected in various parts of th Senegal colony. Natives are also beginning to decorticat by hand, on account of the large pecuniary advantag to be gained. The company are also prepared to erec plant in Bathurst or other parts of the Gambia, and is to be said that a saving of 50 per cent. in freight spac is effected if the ground nuts be shipped after bein decorticated.

The rate of freight should vary for the nuts in the different states. The difference in the freight woul enable the trading firms to pay an encouraging [illegible] to the natives for decorticating nuts, and, as a cons quence, the demand on shipping space would be great reduced, but if the idea is to be encouraged as it deserve prompt steps should be taken by the Shipping Controll in order that they may materialise in time for the oper tions of the next crop, first to encourage the natives decorticate the nuts, and secondly, to facilitate t installation of plant by the various firms to commen the decortication.

The yield of decorticated nuts per ton is :—8 cwts. oil, 12 cwts. of cake, and that of nuts in the shell is about 5 to 6 cwts. of oil, 8 cwts. of cake, 6 cwts. of empty shells (which have no nutritive value), and which are useful only as a combustible.

Decorticated nuts have been shipped from India for many years past. These generally reach Europe in poor condition, partly owing to faulty methods of decorti- cation, causing damage to the kernels, and partly to the long voyage through hot regions. For the last few years decorticated ground nuts have been shipped from

Northern Nigeria, and in spite of the rail journey to the coast of about 700 miles and a sea voyage of about three weeks, these reach Europe in good condition, and can be used for the production of edible oil of good quality. Ground nuts properly decorticated in Senegal should reach Europe in excellent condition, as the average distance of transport by rail would only be about 120 to 200 miles, followed by a sea voyage of ten to fourteen days, mostly in temperate regions. The chief points against the decortication of the nuts in the country of origin are (1) the demand for oil of high quality prepared from nuts shipped in the shell, and (2) the interference with the native custom of selling nuts in the shell.

THE SHEA NUT.

CHAPTER IV.

THE SHEA NUT.

THE shea-butter tree was originally brought to our notice by Mungo Park, and named after him, *Butyrospermum parkii*. The shea-butter grows everywhere in West and West-Central Africa, where the oil palm does not. In Northern Nigeria especially, it flourishes over large areas. Vast and unexploited supplies exist also in the North of Ashanti beyond the evergreen forest. It is content with less rain than the oil palm requires. The vegetable fat from the nut of this tree is used by the West African natives as a food, and has been employed in this country in the manufacture of candles, and mixed with other oils, in soap-making. It is now within the scope of modern chemistry to find some means of preparing and preserving this vegetable fat so that it is an exportable form of butter. It is far nicer in taste, and far more wholesome than some of the present substitutes for the fat derived from cow's milk.

The shea tree grows to a height of 45 to 60 feet or even more. The trunk reaches a diameter of 9 feet or over, and is covered with rough greyish bark. The reddish-coloured wood is hard, heavy, and difficult to work, but is used by the natives for making pestles, mortars, and other implements. The leaves are elongated, glabrous when fully developed, but downy when quite young, and measure from 4 to 10 inches in length and $1\frac{1}{4}$ to $2\frac{3}{4}$ inches in width, each leaf being borne on a petiole from

1¼ to 6½ inches in length. The flowers appear from January to March, according to the climate and the situation of the tree. The white scented flowers are borne in globular corymbs at the extremities of the branches. The fruit ripens from May to September, but principally in the latter part of July. It is spherical or ellipsoidal in shape, somewhat resembling a plum, and measures from 1½ to 2 inches in length and from 1¼ to 1¾ inches in diameter. The fruit consists of an outer succulent pulp, of a yellowish or blackish-green colour when ripe, enclosing usually one, or sometimes two or three nuts. The pulp has a pleasant flavour, and is largely eaten by the natives as a fruit. When ripe the fruit falls to the ground, the pulp being then often consumed by sheep and swine. The nuts generally measure rather less than 1½ inches in length and 1 inch in diameter. The shell is usually of a light brown colour, and resembles the shell of a Spanish chestnut; on drying it becomes hard and brittle, and can then be easily removed. The kernel is soft and yellowish when fresh, but when dry it becomes firm and turns a dark chocolate-brown colour. The dry kernels vary in size and weight; large kernels generally have an average weight of 4½ to 5 grains, whilst small kernels may weigh only 2¾ grains each. The fresh fruit is composed of from 40 to 65 per cent. of pulp, and 35 to 60 per cent. of fresh nuts, the average being about 49 per cent. of nuts. The fresh nuts yield on drying 57 per cent. of sun-dried nuts, or 39 per cent. of sun-dried kernels, containing 5 to 6 per cent. of moisture, and in a condition suitable for export. A native must gather and work up nearly 5¼ tons of fruit in order to prepare 1 ton of kernels for export.

The shea tree requires a deep soil rich in humus, and is particularly abundant on soils composed of sandy clay or of lateritic detritus.

It does not grow in marshy land, or in land liable to be flooded, or on heavy clay soils, but prefers the slopes of hills, and rocky or sandy plains. Although the tree is found in the forest or in the bush, it does not reach its maximum growth under these conditions, since it is often stunted owing to bush fires and the shading effect of more rapidly growing plants and trees. The tree flourishes best in open situations, such as the clearings round villages, and attempts are being made in Northern Nigeria and elsewhere to induce the natives to clear away the bush around the trees with a view to prevent damage by fire. Laws have also been made in the Upper Senegal and Niger region to prevent the cutting down of this valuable tree when land is being cleared for the planting of crops. Although the tree does not appear to be cultivated in the full sense of the word in any district, it is usual for the natives to leave the mature trees when clearing land. The tree is easy to propagate from seed, but grows comparatively slowly, taking about thirty years to reach maturity, whilst it does not bear fruit until from twelve to fifteen years of age. It is evident, therefore, that the establishment of plantations would be a tedious operation, and in view of the irregular yield of nuts, it might also be unprofitable

Such considerations would, of course, be most important in the event of attempts being made to establish oil mills on the spot in West Africa. A native is able to gather 100 lbs. of fruit per day of nine hours in a good season; but any estimate must, of course, depend largely

on the nature of the district and the productivity of the trees.

The fruit, when ripe, drops to the ground and is collected; the succulent pulp is then removed by washing or by allowing the fruit to rot in pits dug in the ground. The nuts are dried in the sun, or in a rough kiln or oven built of earth. The shells are then removed by crushing in a mortar and vanning. A native is able to shell 250 lbs. of nuts per day. Although nuts in the shell have been exported, it is better to shell the nuts on the spot, as the shells are valueless, and comprise about 30 per cent. by weight of the dried nuts.

Probably sun-dried kernels will be found best, as the native process of drying in ovens is rather liable to cause damage to the kernels, with consequent deterioration of the fat.

Generally speaking, the collection and preparation of nuts and of shea butter is carried out by women, the men being employed in transporting the kernels or butter to the local markets.

The question as to whether it be better for the natives to sell the kernels, or to prepare and sell shea butter, depends almost entirely on local conditions of labour and transport. In districts remote from railways or navigable rivers it appears that the preparation and sale of shea butter will give the greater profit; but, in view of the fact that the native methods for the preparation of the butter are inefficient, it appears better on the whole that the native should be encouraged to sell the dried kernels. The transport of the butter on a large scale is also a matter of some difficulty, as it must be packed in casks before being placed on board ship.

A French firm tried the experiment of sending out to West Africa thin tinned sheet-iron which could be folded into boxes. In this case the cost of material for packing 1 ton of butter is said to have been only 13s.

The fact that the residual oil-cake from shea kernels does not fetch a high price in European markets renders it possible that it may ultimately be found more profitable to prepare the fat in West Africa. The preparation of the fat or butter from the kernels as practised by the natives is a tedious and wasteful process: one native can prepare about 8 lbs. in one day, but more than half the fat is not extracted from the kernels, and is thus altogether wasted. After the removal of the nut shells the kernels are roasted in a kind of oven built of earth, in which the kernels are placed upon grids of sticks. This roasting appears to serve two purposes—that of rendering the kernels easier to grind, and also of coagulating the latex and preventing it from being extracted with the fat, which it would contaminate. The roasted kernels are then crushed in a mortar or between two flat stones, and the crushed mass is boiled with water, the fat being skimmed off as it rises to the top and purified by treatment with water and by straining. The methods employed in different localities are the same in principle, but vary in detail. The prepared butter is generally stored in large empty gourds, in which it is allowed to solidify. When required for transport it is removed from the gourds and wrapped in leaves, forming a spherical or ovoid mass usually weighing 40 lbs. and upwards.

THE CACAO BEAN.

PLATE VIII.

A Cacao Nursery in West Africa.

CHAPTER V.

THE CACAO BEAN.

Cocoa, one of the few natural products which serves equally well as food or drink, was, not inappropriately, described by Linnæus as "the food of the Gods." The British Navy recognises its nourishing and stimulating qualities by serving it out daily. The British Army also supplies it to its men almost as frequently.

The powder or essence, which is in domestic use, is the dry cake (ground into flour) of the kernel of the cacao bean, after it has been separated from the bean itself, and after the greater percentage of its natural oil or butter has been extracted by crushing, and pressing under a hydraulic press.

The separation of the kernel or "nib" from the bean is obtained by roasting the beans, then passing them through a cooling chamber, and, finally, cracking them by a machine which winnows the shells and dust by a powerful blast. In the making of chocolate, the butter is not extracted, but the sugar and other flavourings are added to the "nibs" and all ground together. The chemical analysis of cacao nibs and cocoa essence is :—

	Cacao Nibs.	Cocoa Essence.
Cocoa-butter,	50 parts	30 parts
Albuminoid substances,	16 „	22 „
Carbohydrates,	21 „	30 „
Theobromine,	1·5 „	2 „
Salts,	3·5 „	5 „
Other constituents,	8 „	11 „

Cocoa-butter is one of the most delicately flavoured and expensive edible fats known to science. When clarified, it is of a pale yellow colour, and only becomes rancid when subjected to excessive heat or light. In ordinary times it is far too expensive to be used as a food, except for making the finest chocolate and the most expensive confectionery, where ordinary fats like lard, suet, margarine, or butter are too impure and coarse to use. For the same reason some of the most valuable ointments and toilet preparations are made from the cocoa-butter.

During the war, however, when the scarcity of sugar restricted the making of chocolate, and lard—the ordinary housewife's cooking fat—soared to 1s. 6d. and more per pound, cocoa-butter came into use for cooking any article from sweet pastries to fried fish and chipped potatoes.

The peculiar flavour of the uncooked product, distasteful to most adults, can be eliminated, not only by the addition of a little essence of lemon (an important fact to remember when the fat has gone slightly rancid, owing to long storage in factories), but also by the process of cooking.

When the fat has been heated for a short time it almost entirely loses its yellow colour, and also its flavour, and becomes a white neutral fat. Hence, if it is essential not to have any flavour of any sort in the resulting articles, all that has to be done is to heat the oil for a few minutes in an ordinary saucepan. It will be found that the resulting fat can be used for frying fish, making chip potatoes, and puddings of all sorts without any trace of cocoa flavour being apparent.

One pound does the work of 1½ to 2 lbs. of lard or suet, because it is far finer and purer than these, and also is free from all moisture. The pastry produced is much finer and lighter than pastry made from coarser fats.

The output of cacao in British possessions amounts to over 40 per cent. of the world's production, and the proportion is increasing.

In the years 1913, 1914, and 1915 the total world's production was respectively 255,400 tons, 273,600 tons, and 288,400 tons. British colonies produced respectively 87,528 tons, 100,169 tons, and 123,966 tons.

The Gold Coast alone produced in 1915 77,418 tons, equal to 25 per cent. of the total amount.

Brazil, Guayaquil in Ecuador, Grenada, and Trinidad are the principal cacao-producing centres in the New World. Of these, the Trinidad bean is said to be the largest and finest flavoured, the oldest estates (almost all in the hands of the original Spanish and French families) lying in the Northern Valleys of Santa Cruz, Maracas, and Arima. Montserrat and Naparima are also great cacao districts. Charles Kingsley in his *At Last* describes the cacao plantations in Trinidad.

Grenada produces a smaller bean than Trinidad, possibly owing to the prevalence of closer planting and want of artificial shade. The cacao of Guatemala was once monopolised for use by the Spanish Court, and "Soconosco" is still of excellent quality. Para and Bahia in Brazil produce some of the smallest beans, but their flavour is mild and pleasant. Columbia, Venezuela, Jamaica, Dominica, St. Lucia, Tobago, Guadaloupe, Cuba, Martinique, San Domingo, British, Dutch, and French

Guiana also cultivate this product. In the last-named colony, a forest of the wild plant was discovered about 1734 on the banks of a tributary of the Yari River. From this forest seeds were taken and the industry started.

Just before the present war considerable areas, amounting to about 5,000 acres in all, were planted with cacao in Uganda, and the planters were very hopeful of results, judging by previous experiments on a smaller scale. During the past four years, however, such results as have been forthcoming have not fulfilled expectations, the yields not coming up to what had been expected.

Uganda, however, like most other planting countries, has suffered during the war from the fact that considerable numbers of plantation owners and managers have been on active service. In addition, labour has been considerably affected, and planters in the meantime have been attracted by the apparently better prospects attaching to Para rubber.

In the Old World Robert Louis Stevenson was an early pioneer of the cacao industry in Samoa.* The Dutch East Indies and Ceylon also produce large quantities. In Africa, the islands of S. Thomé and Principe were for many years the most famous, and Messrs. Cadbury at one time bought most of their cacao from this source. From 1908 for some years, however, these islands were boycotted by many firms, owing to the conditions of slavery said to exist. The Portuguese Government have now improved all faulty conditions. From 1911, however, British West Africa (especially the Gold Coast Colony) became the principal cacao-producing country in the world, the quantity produced that year

* *Vailima Letters.*

being 44,828 tons. Messrs. Cadbury and Fry now have cacao plantations of their own in Ashanti.

The birth and growth of the cacao industry in the Gold Coast reads like romance. Totteh Quarshie, of Christianburg, towards the end of the nineteenth century, brought a few beans from Fernando Po, where he had been working as a blacksmith. Planting them, and nursing the seeds, his little enterprise soon became profitable. Others soon imitated him. In 1891 the first shipment of about 80 lbs., valued at £4, was made to this country, since when it has leaped rapidly to about 80,000 tons, valued at about four millions sterling—more than a-third of the total cacao production of the world. Every pound has been grown by native farmers, and the family incomes of cacao-growers have been multiplied a hundredfold or more, many amounting to between one and two thousand pounds sterling yearly, a few being even larger. Cacao is now also being grown in Togoland, Cameroons, Sierra Leone, and Nigeria.

In Nigeria, the export of cacao has increased from 99,000 cwts., valued at £172,000, in 1914, to over 200,000 cwts., valued at about £400,000. Ibadan is the largest producing centre, and three native cacao instructors are employed in the Calabar and Abeokuta provinces and in the Agege district. In the first-named, cacao-planting competitions are encouraged by the Government. In the last-named, tests made with the Hamel Smith drying machine, to compare the effects of sun-drying and machine-drying, showed the percentage of alkaloids in the artificially-dried product to be 2·05 as compared with 1·82 in the sun-dried, but the cost was three times as great.

Owing to the restrictions upon the imports of cocoa into Europe during the war, the figures give no accurate estimate of the enormous growth of the cacao industry. We have, therefore, only given below the imports into New York during 1915-17 inclusive, which speak volumes :

Imported into New York—January-December.	1917.	1916.	1915.
All growths,	2,490,237	1,567,484	1,441,517
Including—			
Guayaquils,	391,530	265,812	208,183
Trinidads,	182,449	157,277	160,991
Caracas,	180,091	111,749	156,101
Bahia,	596,513	248,740	272,586
Sanchez,	322,001	319,238	265,348
St. Thomé,	93,508	59,071	27,646
Other African,	593,782	304,783	203,109
Delivered for Consumption—			
All growths,	2,276,111	1,384,769	1,192,922
Including—			
Guayaquils,	348,808	157,893	171,045
Trinidads,	174,905	155,467	144,978
Caracas,	136,303	106,317	115,090
Bahia,	558,633	235,863	206,221
Sanchez,	328,138	284,136	202,212
St. Thomé,	87,809	58,500	33,004
Other African,	543,091	300,971	185,330

During the summer of 1918, however, the American Government placed restrictions on the importation of cocoa, licence to West African importers being refused owing to distance and tonnage difficulties, thus resulting in an embargo on the West African product. The British West African Association, by a deputation (of which the author was one) received by the American Embassy, obtained a modification of this embargo for 1919, thus saving the West African cacao industry from disaster.

The cacao tree grows to a height of from 12 to 25 feet. Three to six lateral branches are formed when it is bud

a few feet from the ground, but only when these are matured does a leader spring from the side. The leaves are large and undivided. The flowers are clustered and small, and seldom does more than one develop into fruit. The plant has a long taproot, and it succeeds best in a rich, deep, well-drained loam (or soil formed by the decomposition of volcanic rocks) in sheltered valleys with a southern or western aspect, 200 to 500 feet above sea level. In Trinidad, Cuba, and British Guiana it has been grown successfully on a lower level. Proximity to the seashore is said to be an advantage, but exposure to the direct influence of the sea-breeze is undesirable. The tree grows wild in the Central American forests, and varieties have been found in Jamaica and other West Indian islands, and in South America. The Mexicans and the Aztecs, when discovered by the Spaniards, both used the beans of the tree for currency side by side with gold ingots. The Spaniards also relate that as a sacred rite "the blood of slain fowls was sprinkled over the land to be sown with the cultivated product." Possibly there was some connection with a similar practice which the author noticed in West Africa, around kola and cacao trees, and which a native chief informed him was to attract the red ant from infesting the trees.*

The best known varieties of seed for planting purposes are the Criollo, Forastero, and Calabacilla.

The *Criollo* ("native") is of average size with a "pinched" neck and a curving point, light in colour and delicate in flavour. Their cotyledons are usually pale or white.

* Sierra Leone: Its People, Products, and Secret Societies," p. 55.

The *Forastero* (" foreign ") is long and deeply furrowed, but regular in shape and rough surfaced, flatter as a rule than the criollo. Their cotyledons are usually purple.

The *Calabacilla* (" little calabash ") is generally smooth and round. Otherwise there is little to distinguish it from the Forastero, the hardy character of which it also shares.

Where the Criollo and Forastero varieties are cultivated in close proximity, cross-fertilisation takes place between them, and the characters of each type may be found merged in the progeny. This is particularly noticeable in Ceylon. The seeds are either sown in a nursery or " at stake."

(The author participated in the planting of cacao in West Africa, both on a modern plantation, controlled by Europeans, and on a more primitive one maintained by a native chief. He was thus able to compare the two methods.)

The native practice was (and still is, where the Government have not succeeded in inducing the people to adopt newer methods), after felling the forest, to sow the seed " at stake " in small patches at the beginning of the rainy season, in roughly prepared beds close to the water. Gaps are not filled, and two or three seeds are sown together, the woaklings being cut out not later than the second or third year. Even then the remaining plants are too close together—6 feet intervals being frequent—and often in very irregular lines; while the excessive shade caused by close planting often prevents the fruit from forming well, and sometimes produces rot, owing to want of evaporation of moisture. On the other

hand, the dense foliage makes weeding unnecessary, and is therefore economical from this point of view.

In Grenada and British West Indies, where planting at stake is frequent, 8 feet of space only is given between each plant, thus forming a denser foliage and dispensing with any other shading. Five hundred trees to the acre can thus be raised, but the method is not so suitable to open valleys or plains as to hillside plantations.

Seeds "at stake" are protected by a palm-leaf or similar covering, and except in purely native plantations, all but the strongest plants are removed when the seedlings reach 1 foot in height.

Sowing "at stake" is not recommended where frequent periods of dry weather occur during the rainy season, as the young cacao trees demand a moist soil during the first four or five months of their existence.

If not sown "at stake," cacao seeds are planted either in a nursery made of wicker and palm-leaf, or in bamboo pots on the spot upon which they are definitely intended to grow. The seeds are planted 4 inches apart in rows at intervals of 9 inches, the stringy centre of the pod being planted downwards.

When the seedlings are about a foot high they can be planted out, an unbroken wall of earth being taken up with each seedling.

A month or two before transplanting takes place holes about 3 feet square and 2 feet deep are dug, the sub-soil being thrown into a heap alongside the hole. On steep hill-slopes this soil is best placed on the lower side of the hole. If water stagnates in the holes this indicates that drainage is necessary and must receive attention before planting commences.

A few days previous to transplanting the young cacao plants, the holes are filled with any rich surface-soil in the neighbourhood, or, should this not be available, a good layer of animal manure is placed at the bottom of the hole.

The best time for planting cacao is at the commencement of the rainy season, as this gives the young plants sufficient time to become thoroughly established before the dry weather appears. Having partly accustomed the young nursery plants to the conditions of the open field, by removing all shade from them, transplanting commences during a spell of wet or cloudy weather. The soil is first thoroughly saturated with water in the baskets or pots, to facilitate the subsequent removal of the plants. The roots are disturbed as little as possible, and not buried too deeply in the ground; it is sufficient if the surface-soil is on a level with the top of the ball of earth taken from the pot or basket. Should this ball be broken, the roots in the ground are buried so that the surface-soil just reaches the point where the stem issues from the soil in the pot. Large numbers of young cacao plants fail to grow satisfactorily if they have been planted too deeply or too far out of the ground. The soil is firmly pressed around the ball of earth enclosing the roots; but it is almost impossible to carry out transplanting without slightly disturbing the roots.

Leafy twigs or palm leaves bent over in the form of a cage, provide the necessary shade until the young plants start into growth.

Should a spell of dry weather set in before they become established, as many as 30 per cent. of the plants perish during the first year following the establishment

PLATE IX.

Castle Beans upon specially pruned trees.

of the plantation. As the greatest percentage of organic matter is almost invariably found in the uppermost layers of a soil, unless this surface-soil is protected the organic matter is liable to be washed away by heavy rains. There is, however, less loss of organic matter occurring on an estate where the soil is held together by a mass of fibrous roots—*e.g.*, where all the vacant spaces between the trees are occupied by catch-crops. Some planters affirm that the soil is best protected by allowing weeds to grow, and by cutting them down at intervals. There is something to be said in favour of this practice, especially on hilly lands, for the surface-soil is prevented from being washed away by the network of fibrous roots formed by grasses and similar weeds. When they are cut down, the plant-foods which they have extracted from the soil are in a measure returned as soon as decomposition sets in.

The best season to prune is when the sap is least active, and this frequently coincides with the end of the principal crop season. Most cacao trees carry more or less fruit all through the year, but they produce more towards the end of the rainy season. The removal of large branches is very rarely necessary from cacao trees which have been always properly pruned; indeed, the best pruned trees are those from which all undesirable growths have been removed with a pocket pruning-knife.

In Trinidad, where cacao plants are planted about 12 feet apart, large forest trees used to be planted for shade purposes—usually the *Bois Immortelle*—while in Samoa trees are often left standing for this purpose at intervals when the forest is being cleared. Rubber and bread

fruit for permanent shade, and smaller "catch-crops" or "side-crops" for temporary shade, are now frequently used as being more remunerative.

In West Africa the banana is used for temporary shade purposes, and gives a profitable local return while the cacao tree is growing. Cassava or tapioca is also employed, but is not recommended, as it takes too much nourishment from the soil.

Manuring, except for delicate plants, and upon soil lacking necessary chemical constituents, is not actually necessary until after the first crops, although a moderate application often quickens growth and production. As soon, however, as the crop-taking has begun, regular manuring is necessary to ensure permanent and improving crops.

The leaves of the plant, at first a tender yellowish-brown, ultimately turn to a bright green. They often grow to 14 or 18 inches in length.

Scale insects attack the leaves, and grubs will quickly rot the limbs and trunks, unless attended to. If left to nature, lichen, moss, ferns, and vines will encroach upon the tree.

The greatest number of flowers are produced on the stem and principal branches, and a tree may continue to bear flowers and fruit from the same areas for many consecutive years. The flower is small, considering the size of the fruit. Flowers may be found on the trees throughout the year (and clusters of the pink and yellow blossoms may often be found on the trunk itself), but the greatest number are usually present about six months before the principal crop season.

Cacao flowers are so constructed that outside and apparent

PLATE X.

is essential for pollination. Many insects are doubtless instrumental in this connection.

Five or six months usually elapse between flowering and fruiting. The first flowers are not allowed to produce pods, as this exhausts the tree.

The average number of pods which a healthy cacao tree matures per year is approximately seventy, so that only about 1 per cent. of the flowers yields mature fruit.

The beans are found in the pods in five longitudinal rows; ten beans may be traced in each row, but rarely more than 45 properly developed beans are found.

During the last months of ripening, squirrels, monkeys, rats, deer, and birds will frequently harass the beans; but if snakes abound, as they usually do in the cacao regions, they will destroy and prevent more of these depredators than a hunter's gun.

Cacao produces when about four years old. From the twelfth to the sixteenth year it is at full maturity. The cacao-tree bears nearly all the year round after it has reached the age of five years, but only two harvests are, as a rule, made. The crop varies from 1 to 7 lbs. per tree, and as much as 4 cwts. per acre. Eleven pods produce about a pound of cured beans, each pod containing from 36 to 42 beans on a fully mature tree.

The fruit is yellow and red on the side nearest the sun, the rind thick, the pulp sweet, the seeds numerous, and covered with a thin brown skin or shell.

The native cacao-grower too frequently collects the pods at a time when he can gather the maximum quantity, and often, in consequence, takes over-ripe and under-ripe fruit. He also is inclined to pull off the pods, often

thereby tearing and injuring the cushion, from or near which the successive crops of flower and fruit proceed, hence the bearing capacity of the tree is subsequently diminished. The correct method is to cut the pods with a knife or cutlass, and only when fully ripe. The pods should sound hollow when tapped with the knuckles.

The native often leaves his heap of collected pods for two or three days without further attention, he then breaks them open, and the medley of beans and pulp are washed and dried in the sun.

On a careful cacao estate, the beans are shaken out of the pods or extracted with spoons—usually by women—as soon as collected. Then they are piled in heaps and covered by sand and banana leaves, or placed in box-like bins with perforated sides and bottoms, and similarly covered with leaves for fermentation. Every twenty-four hours these bins are emptied into others, so that the contents are thoroughly mixed, or, if in heaps, they are turned over daily for four or five days, until the pulp becomes darker, and the temperature raised to about 140° F. The object of this "sweating," as the process is called, is to remove the dark, sour, stieky liquid, a kind of dilute acetic acid. The beans become duller in colour and the skin is expanded.

They are next laid out in trays or on mats to dry in the sun, or are specially machine-dried. In Ceylon and in West Africa, they are also washed or sprinkled over with moisture and polished, the latter process being done by machine in the more modern plantations, and by natives treading upon the beans in more primitive cacao estates.

In Venezuela, in some parts of West Africa, and in other cacao-bearing regions where Spaniards have been dominant, there is a practice of "claying" the beans by dusting over them a fine red earth during the drying process. The bean is said to be protected thereby from mildew, and the aroma is supposed to be preserved. Often, however, this practice degenerates into a mere "weighting" of the cacao. Many brokers and manufacturers do not favour "claying," but others do.

The beans are exported to Europe in bags. The process of their manufacture into cocoa or chocolate in this and other countries the author has described elsewhere.*

The cost of planting and producing cacao varies, of course, like its yield, according to the country, and also according to the labour obtainable.

In Trinidad, for example, land may be obtained for about £1 per acre, and labour costs from 50 to 100 cents per day, while estates are usually planted on the contract system—*i.e.*, the land is cleared at the owner's expense (25s. to £2 per acre), and handed over to a contractor, who drains and plants for his own profit. When he hands it back, the proprietor pays 1s. 3d. per bearing tree, and about half-price for non-bearing ones.

In Samoa the Vice-Consul estimates about £2,800 to start a plantation, and £30 to £40 as the cost per acre from the clearing to the first crop.

The Governor of Fernando Po says that capital invested yields interest in five to six years, and in seven or eight years the whole should be reimbursed.

A native farmer, writing in the *Gold Coast Leader* in

* "Romance of Modern Commerce" (Seeley & Co., London).

1916, gave the following estimate of initial expenses on a small native estate of 200 feet by 400 feet :—

To Clear and Maintain.*

1st year, clearing of bush,	£4	0	0
Felling large trees,	8	0	0
Planting young cacao trees,	2	0	0
Clearing weeds,	8	0	0
	£22	0	0

The trees generally yield as follows :—

4th year, 3 loads at 20s,	£3	0	0
5th year, 6 loads at 20s,	6	0	0
6th year, 12 loads at 20s,	12	0	0
	£21	0	0

During these years payment to overseers for plucking and drying is 3s. a load, and transport for 20 miles about 4s. a load.

The future lies with the producer of high-grade cocoa at the lowest cost. Speeding-up and efficiency must be the watchword on the tropical estates as well as in the factories at home.

* The cost, of course, has gone up since this was written, but so also has the price.

THE SOYA BEAN, COTTON SEED, AND SESAME.

CHAPTER VI.

THE SOYA BEAN, COTTON SEED, AND SESAME.

The Soya bean comes from a leguminous plant originally found in a wild state in the region from Cochin China to the south of Japan and Java. It has been cultivated from very ancient times as a food plant, principally in China and Japan; but although grown in these countries for such an extended period, its cultivation seems to have spread very slowly to the surrounding countries, and has only been introduced into India during comparatively modern times.

In the Southern part of the U.S.A., where it is now extensively grown, numerous experiments are being carried out to ascertain the varieties best suited to the different soils and climates. It is also grown in various parts of Europe, but not to any great extent.

The plant has branching hairy stems, with more or less hairy leaves, broad flowers pale lilac or violet-coloured, and three to five seeded pods covered like the stem with stiff hairs. The seeds vary in colour from whitish and yellowish to green, brown, and black, and in shape from spherical to elliptical.

Under favourable conditions the plant may reach a height of 4 feet or more. Very often more than 100 pods have been obtained from one plant, but in a field crop a good average would be 40. The flowers are self pollinated; thus the yield is entirely independent of insects

and the plant free from an important obstacle in the way of introduction to new regions. A crop of seed is ensured wherever conditions are such as to allow the plants to make the proper vegetative growth and reach maturity.

There are over 200 varieties of Soya bean, which are distinguished according to the colour, size and shape of the seed, and the time required for the plants to reach maturity. This large number of varieties can be formed into six groups—yellow, greenish-yellow, black, brown, green and white.

The yellow variety has the largest growth and is rich in oil (17 to 19 per cent.), albuminoids, carbohydrates, and nitrogen. Under average conditions it grows from 3 to 5 feet, and requires from 120 to 150 days to mature a crop of seed. The average yield should be 30 bushels per acre (600 kilograms). Under no circumstances should this seed be planted more than 2 inches deep. The crop can be readily harvested with machinery, and is frequently gathered with a grain-binder. One of the yellow varieties, the "Southern," has given very good results in Natal and in the Northern Transvaal. In West Africa also progress has been made, and a larger amount of oil has been obtained there than in Manchuria, Japan, or the United States, and, just before the war, this variety was being experimented with in East Africa and the Sudan.

The greenish-yellow, a medium late variety, is vigorous but not coarse, growing 3 to 4 feet high with numerous branches, none close to the ground.

The green is grown extensively in N. China, and, containing about 17 per cent. of oil, is considered to be one

of the best eating beans. The seed is kidney-shaped, and larger in size than any other variety. This plant matures in 90 days, grows to about 3 feet high, and is very coarse.

The white variety grows abundantly in China, Darjeeling, Himalaya Mountains, and in India is known as Glycine Soja-Bhat. It is one of the staple foods of both countries, and contains about 16·60 per cent. of oil.

The brown matures in 110 days, and gives a large yield of seed, but its tall growth conduces to fall and the seeds break easily on threshing.

The black bean requires a very long season in which to mature its full development, and is, therefore, adapted only to the cotton-belt. The seed is rather small, olongated and flat, and is covered with a powdery bloom which makes it look dusty. The plant grows from 4 to 6 feet high, but has a fine stem, and so is useful for hay. It contains 16·80 per cent. of oil. After all the oil has been extracted, the residue is used in large quantities by the Chinese and Japanese, who make a favourite condiment called *Shoju*—soy sauce—which is of a darkish brown colour, and is largely exported to Europe for sauce-making purposes.

In Japan, the Soya bean grows well in soil of rather strong character, while in Europe and America it has done well on comparatively light soils, often giving an abundant crop on soils too poor to grow clover.

In S. Carolina, excellent crops are obtained on sandy limestones or marly soils. The Soya bean is not injured by light frosts, and while possessed of excellent drought resisting qualities, it, at the same time, seems to be able to survive a period of excess of moisture better than cow-peas or even maize.

The Soya bean is especially adapted to the maize and cotton belts, where the later varieties grow exceptionally well. Generally speaking, the Soya bean requires the same temperature as maize, the soil requirements being much the same; it will make a good growth on poorer soil than maize requires, provided that inoculation is present. The Soya bean makes the best development on fairly fertile loams. Where the soil is good and a crop of hay or green fodder is desired, good results may be obtained by sowing broadcast. If, however, a crop of beans is desired it is best to plant in drills from 2 to 3 feet apart, according to the quality of the soil. When sown broadcast, about a bushel of seed is required, and when put in with a drill, from half to three-quarters of a bushel is required. When a seed crop is required, enough seed should be used to give five or six plants per foot in the row, the rows being on an average 2½ feet apart.

The Soya bean can be planted any time from early spring up to midsummer. Generally, early plantings require more time to mature than late plantings, the difference in the same variety often amounting to as much as three weeks.

Under ordinary conditions, 25 to 40 bushels of seed per acre (from 1,280 to 2,100 kilograms per hectare) would be an average yield. On comparatively poor soils 20 bushels of seed per acre can generally be obtained.

Average Analyses of the Seed of the Six Varieties of Soya Beans.

Water,		7·70
Fresh or air-dry substance	Fibre,	4·60
	Fat,	20·35
	Nitrogen free extract,	26·15
	Protein,	35·40
	Ash,	5·79
		100·0

In harvesting, it is better to cut the pods before they are quite mature. If too ripe, they are inclined to burst during the process of drying and carrying.

This bean is an invaluable crop in all planting districts. It can be planted in coconut plantations, to enrich the soil, give fodder to the working cattle, and be a source of profit in supplying food to the natives; it also helps in keeping down the weeds.

Soya bean meal or cake has been found to be a most excellent food for dairy cows. It increases the quantity of the milk and improves the quality of the butter, giving it a firm texture and thus improving its keeping qualities. Two pounds of meal per day is a fair ration for a dairy cow, the cake or meal should be first softened in water and well mixed with lucerne or any other forage given.

The following is an analysis indicating its nutritious qualities :—

	Cake	Meal.
Water,	12·70	3·80
Oil,	11·07	11·33
Albuminoids,	38·52	43·05
Digestible carbo-hydrates,	26·51	30·77
Woody fibre,	5·80	5·45
Mineral waters,	5·05	5·35
Sand and silica,	0·35	0·25
Total,	100·0	100·0

Cotton-seed oil belongs to the class of semi-drying oils, but has recently come into use as a salad or table oil, as a substitute for lard, and in the manufacture of oleo-margarine, the cheaper qualities only passing to the soap factory.

The Americans first bestowed the care on cotton-seed oil which brought it into prominence. As the seed is ginned it is removed to splendid storage accommodation in the mills. Raised to the top of the store by bucket elevators, a screw "conveyor" distributes it wherever available. As required, it drops into another distributor, which transfers the seed to the revolving "boll screen," a cylinder perforated with holes sufficiently large to pass the seed, and retain the bolls, stalks, or other large impurities. From the screen the seed passes to another revolving perforated screen, which separates smaller impurities—*e.g.*, sand, dust, etc.

The clean seed is next conveyed to the "linters," a saw-gin which removes the short lint, thence to the "hullers," an outer cylinder and an inner drum with knives set in both. The "hullers" having broken the shells and partly cut up the kernels, a revolving screen and an oscillating separator or "shaker" eliminate the hulls. The remaining kernels are crushed between heavy rollers, heated, and shaped into cakes, which, wrapped in hair cloths, are packed into presses. The squeezed-out oil is pumped into a settling tank, where any impurities sink to the bottom. The oil cake, which fetches about a quarter of the price of the oil, is used for fattening cattle and exported. Demarganated cotton-seed oil is sometimes called "winter oil." Kapok oil from the silk-cotton tree is similarly expressed for butter substitutes, but this is largely a Dutch industry.

Sesame or "gingelly" oil, also a semi-drying oil, is bland, nearly colourless, and without smell. It comes from the flat seed of an herb or plant which grows from

2 to 4 feet high, in India, Palestine, Siam, China, Asia Minor, and other sub-tropical countries. The plant is said to have come from the Indian Archipelago, its flowers are yellow or pink in colour, and its seeds vary from white to reddish-brown or black. The seeds contain 50 per cent. of oil, which is used in India for cooking purposes, anointing the body, for illumination, and soap manufacture. Being edible, the oil is used in many tropical countries to flavour bread and cake. The soot obtained in burning the oil is used as one of the ingredients of Indian Ink. The Palestine seed is said to be the [illegible]. In Europe it is used as a substitute for olive oil, although it is commercially more important than the latter oil. Marseilles is the greatest importer.

Hempseed.—Among minor edible oils, but of the drying class, those from hempseed and candlenuts deserve a brief notice.

Hempseed oil is produced in large quantities in Russia, and as there is a considerable demand for it on the Continent, deserves greater attention from those of our colonies which could cultivate hemp.

The seed contains from 30 to 35 per cent. of oil, yielding from 25 to 30 per cent. after the extracting process. Of a light green or greenish-yellow colour when freshly extracted, it changes, when kept, to brownish-yellow. The cold-pressed oil only is edible, the remainder is used for burning or for soft soaps, paints, and varnishes. The cake is a highly nutritious cattle food, containing 32·30 of protein.

Candlenuts. — Candlenuts (*Aleurites triloba*), coming chiefly from Mauritius and Hong Kong, have been found

to contain over 60 per cent. of pale brownish-yellow liquid oil in their kernels, and a seed-crushing firm has estimated that the value of this oil should be almost equal to that of palm oil, while the residual cake could be used as a fertiliser. The shells are valueless, therefore the kernels alone should be exported.

BABASSU AND PARAGUAY KERNELS AND MISCELLANEOUS OIL-NUTS.

CHAPTER VII.

BABASSU AND PARAGUAY KERNELS AND MISCELLANEOUS OIL-NUTS.

A RECENT type of kernel, known as Coco babassu and Lassoba, is derived from a species of *Attalea*, possibly *A. funifera*, Mart. The tree is stated to be abundant in the State of Maranham, Brazil (*Dipl. and Cons. Reps., Ann. Ser.*, No. 5,526; *Report on the Trade of Para*, 1914). Considerable quantities of Babassu kernels have been exported lately, the quantity in 1916 amounting to nearly 1,500 tons. The greater part of the kernels appear to have been obtained by hand-shelling, the nuts being placed on end in a hole in a board and struck with an axe; but British machinery for shelling the nuts is stated to have been introduced.

The kernels have been crushed on a fairly large scale in this country, and there seems to be every prospect of increased supplies being brought here. They are said to have been sold at about £2 per ton less than the price paid for good copra.

The fruit weighs on an average about 45 grams, and consists of an outer fibrous pericarp enclosing a hard-shelled nut containing several kernels. A single fruit examined at the Imperial Institute contained five kernels, but, from the size and formation of the kernels as exported from Brazil, this is perhaps an unusually large number.

The kernels are reddish-brown, and of a characteristic

the shells can be cracked by machinery such as is already used for ordinary palm nuts in West Africa. In the case of Babassu nuts, however, like Cohune nuts, the problem of extracting the kernels is more difficult, as the fruits have a fibrous pericarp, the removal of which is generally regarded as necessary before the nuts can be cracked.

For cracking "Babassu" nuts a machine has been constructed by Messrs. Hind & Lund, of Preston. In this machine the nuts are crushed endwise between a fixed steel anvil with a concave depression on the surface and another anvil operated by means of an eccentric device attached to gearing which may be worked either by hand or power. The machine is stated to deal with 40 nuts per minute, and is sold at £25, f.o.b. Liverpool (if 100 machines are ordered at one time).

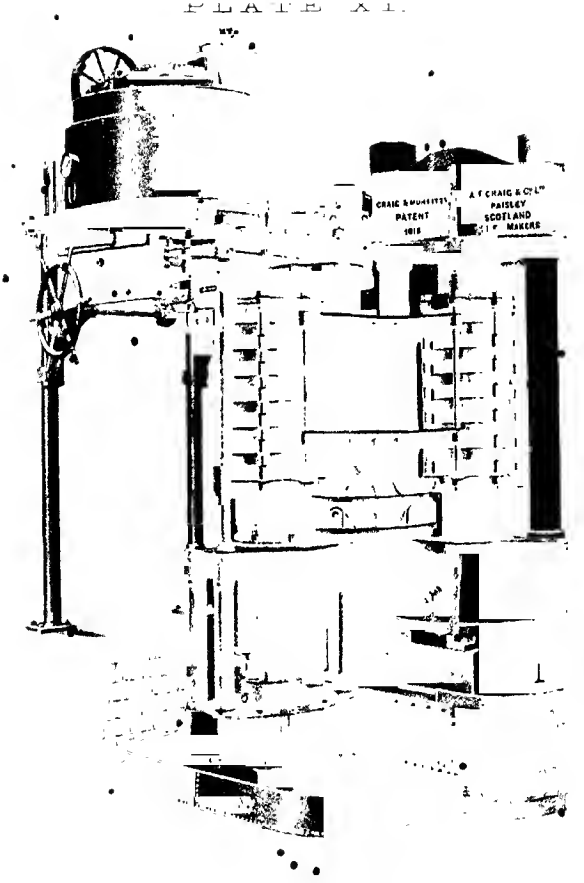
The Downie machine, designed by Wotherspoon, consists essentially of a depulping device for removing the fibrous pericarp, a centrifugal nut-cracker working in conjunction with an oscillating riddle, and also with a brine bath or with water for separating the broken shell from the kernels. The machine is driven by means of a 5 H.P. oil engine.

Another nut-shelling machine, designed to shell "hard nuts, such as the Cohune nut," has been patented by Dyer and Innes-Ward (*English Pat.*, 5687/1913). This machine can deal with 8 to 10 tons of Cohune nuts per day, and requires 1½ H.P.

Both of the last-named machines are devised for Cohune nuts, but the "Babassu," being very similar in hardness, could doubtless be handled by the same machinery.

The Strephonema Nut.—Three new oilseeds from Tropical

PLATE XI.



Craig Revolving Box Press for Copra, Palm Kernels, etc

Africa have been reported as having been received and experimented on by the Imperial Institute during 1917-1918.

The first is the kernel of the *Strephonema*, a tree or shrub confined to Tropical West Africa, and particularly abundant in the Belgian Congo.

The sample consisted of very dark brown kernels, roughly hemispherical in shape, and measuring from 1 to 1½ inches in diameter. Internally the kernels were hard, and of purplish-brown colour. They were found to yield 38·6 per cent. of a bright yellow, rather soft fat, equivalent to a yield of 41·8 per cent. from the dry kernels. The fat was free from unpleasant smell or taste.

The report states that the low saponification value is unusual for a fat of this character. This feature is probably due to the presence of a considerable amount of fatty acid having a low saponification value, and not to the presence of di-glycerides. The yield of glycerine is somewhat low, and would be much higher if di-glycerides were present.

The residual meal left after the extraction of the oil was of chocolate colour, and had an unpleasant astringent taste. It was analysed with the following results:—

	Per cent.
Moisture,	7·3
Crude proteins,	9·6
Consisting of—	
True proteins,	8·2
Other nitrogenous substances,	1·3
Fat,	0·9
Starch, tannin, etc. (by difference),	69·9
Fibre,	9·1
Ash,	3·3

No alkaloids or cyanogenetic glucosides were present.

A considerable quantity of tannin is present, as the

following results show, and the astringent taste of the meal is no doubt due to this :—

	Per cent.
Moisture,	7·3
Matter insoluble in water,	41·3
Extractive matter (non-tannin),	17·7
Tannin,	30·7
Ash,	3·3
Tinometer readings for a 0·5 per cent. tannin solution in a 1 cm. cell, Red	7·4
Yellow,	15·9

Tho meal thus contained a fairly large amount of tannin, but tho extract was of a dark purplish-red colour, and would yield a dark coloured leather, so it seems unlikely that the meal would be of commercial value either as a tanning material or for the manufacture of tanning extract.

This investigation indicates that the yield of fat from these kernels is sufficient to make them of commercial value. For oil seeds, however, to sell readily, especially in the United Kingdom, it is necessary that they should yield a good feeding cake, and tho presence in the meal of a considerable amount of dark coloured tannin would prevent its use for feeding purposes without special preliminary treatment for removal of the tannin.

The N'gore Nut.—The next is the N'gore nut, almost spherical-shaped, bluntly pointed at one end, and measuring from ¾ to 1 inch in diameter. The kernels are brown externally, mostly of pale cream colour within, and of soft consistenco. They yielded 66·2 per cent. of a reddish-yellow viscous oil, equivalent to a yield of 70·7 per cent. from the dry kernels.

The oil, which has an unpleasant odour, possesses an unusually high specific gravity. It is partially soluble in alcohol and completely so in ether, but is not soluble

in light petroleum, although it absorbs this solvent to some extent. In respect of its high specific gravity, viscosity, and behaviour with solvents, it is somewhat similar to castor oil, and the acetyl value shows that, like castor oil, it contains hydroxylated acid. Although the oil has a high iodino value it does not dry on exposure to air in a thin film.

The unpleasant smell and viscous nature of the oil, together with its dark colour, would prevent its use for edible purposes. It yields a dark-coloured soap, but could no doubt be used for making certain kinds of soap. It might also provo useful as a lubricating oil, and could probably be utilised for several purposes to which castor oil is applied.

The residue after extraction of the oil consisted of a cream-coloured meal, having a faint but somewhat unpleasant garlic-like taste. The meal was submitted to chemical examination with the following results :—

	Per cent.
Moisture,	6·8
Crude proteins,	43·4
Consisting of—	
True proteins,	37·6
Other nitrogenous substances,	5·8
Fat,	7·0
Starch, etc. (by difference),	26·9
Fibre,	8·8
Ash,	7·1
Nutrient ratio,	1 : 1
Food units,	153

No alkaloids or cyanogenetic glucosides were present in the meal.

The report adds that the above results indicate that this N'gore meal has a high nutritive value, but owing

to its peculiar character further examination and feeding trials would be necessary in order to ascertain whether it could be used safely as a feeding stuff for animals.

The N'gore kernels furnish a large yield of oil which is of unusual type, but may prove to be of considerable technical value.

The N'kamba Nut, called the *Kamba Nut*.—This sample consisted of pale brown nuts, measuring 1¼ inches in length and 1 inch in diameter. The kernels yielded 14·5 per cent. of a yellow liquid oil, equivalent to a yield of 16·3 per cent. from the dry kernels. The oil is of a non-drying character, and could no doubt be used for various industrial purposes. The yield from the kernels is, however, so small that the latter would be of little value as a commercial source of oil.

The residue after the extraction of the oil from the kernels consisted of a cream-coloured meal having a pleasant and rather sweetish taste. It was submitted to chemical examination, with the following results, which are shown in comparison with those recorded for a sample of palm-kernel meal :—

	N'kamba Meal.	Palm-kernel Meal.
	Per cent.	Per cent.
Moisture,	6·2	15·0
Crude proteins,	18·9	10·0
Consisting of—		
True proteins,	15·5	..
Other nitrogenous substances,	3·4	..
Fat,	1·3	2·0
Starch, etc., (by difference),	68·4	51·0
Fibre,	2·4	9·0
Ash,	2·8	4·0
Nutrient ratio,	1 : 3·8	1 : 2·9
Food units,	119	104

No alkaloids or cyanogenetic glucosides were present in the N'kamba meal.

The above results indicate that N'kamba meal should have a nutritive value about equal to that of palm-kernel meal. The meal appears, however, to contain saponin, as it causes frothing when shaken with water, and an attempt to gain further evidence on this point will be made. There appears to be no record of the use of Heisteria meal as a feeding stuff, and as it may contain saponin, which is an undesirable constituent, it cannot be recommended for this purpose.

A further sample of these kernels received in July, 1917, was found to contain 18·1 per cent. of oil, calculated on the dry kernels, as compared with 16·3 per cent. in the case of the first sample. Two specimens of nuts from the Belgian Congo, which were very similar in appearance to N'kamba nuts, have also been received at the Imperial Institute; they contained 15·6 and 13·2 per cent. of oil respectively, expressed on the dry kernels. In view of the low yield of oil and the doubtful quality of the meal it is improbable that these kernels would be of value in this country, at any rate under present conditions.

The N'kula Nut.—Another nut, less known, but which the author found in abundance in the Liberian forests, and which is not only of pleasant taste but remarkably oily, is known scientifically as *Coula edulis*. This has nothing whatever to do with the stimulating kola nut. The scientific name (rather a foolish one) is a corruption of the native term Nkula, given to this tree in the Gaboon. The nut would, I believe, be a valuable addition to our sources of vegetable oils and materials for food products.

The Kamoot Nut.—Very similar is that of the *Kamoot* or *Butter* and *Tallow tree*, which the author experimented with in Sierra Leone. The fruit of this tree closely resembles the kola acuminate, and is often placed among genuine kola nuts as an adulterant; but it does not contain theine like the kola, and it yields fat and tannin, neither of which are to be obtained from the genuine kola. The fat is ediblo, and can be profitably used in candle-making, margarine, and soap manufacture. As much as 41 per cent. of oil has been obtained from the seeds, and £10 a ton in pre-war times has been obtained for the commodity.

The Sierra Leoneans and the Mendis do not use the tree, but the Temnes, from whom the name Kamoot is borrowed, express the oil for food purposes in the same way as palm oil.* Thoy dry the seeds, parching them over a fire, then pound them in a mortar, add water, and boil, skimming off the fat or oil as it rises to the surface. The tree is propagated by means of seeds, and is usually found near streams, being plentiful in the Savannah districts of Sierra Leone, and particularly in the neighbourhood of the old Christineville Rubbor Estates between Rokelle and Waterloo, where it is called by the Mendis "Jorrah" or "Black Mango." It is also plentiful on the Niger River and Congo district, where the natives call it "Ngoumi," and a trade is done in it with Europe from French West Africa, where it is called by the name of "Lamy."

Dika Nuts.—Another oil-bearing product is the Wild Mango, the fruit of which is like but very inferior to the ordinary Mango.

* See also "Sierra Leone: Its People, Products, and Secret Societies."

The natives eat it, but they attach greater importance to the kernel, from which they make the so-called "Dika" bread, which consists of the bruised kernels warmed and pressed into a cake. It is used largely, when scraped or grated, in stews, and forms a staple article of food amongst the natives.

Decorticated Seeds.—Sun-dried kernels contain 54·3 per cent. of solid fat, having a specific gravity of 0·914 at 40° C.

The fat is considered suitable for soap and candle-making, for which purposes its value is regarded as equal to that of palm-kernel oil—£27 5s. per ton—and if it could be obtained perfectly fresh and pure, it might also equal some of the present substitutes for butter and lard. The commercial valuation of the fat from sun-dried kernels has been given at from £25 to £27 per ton, and that of the kernels probably £10 to £12 per ton. Messrs. Miller Bros.' machine for cracking palm nuts has been tried with success at the Imperial Institute with Dika nuts. It is not considered advisable to ship the nuts whole.

APPENDIX.

COMPANIES AND ASSOCIATIONS INTERESTED IN EDIBLE OILS AND CACAO.

African Association, Liverpool.
African Oil Mills, Liverpool.
American Commerce Co., Bride Street, London, E.C.
Atlantic Coast Development Co., 8 Copthall House, London, E.C.
Benabu, Messrs., London, E.C.
Blandy Bros., London, E.C.
Bridge, R., & Co., Castleton, Manchester (Machinery).
British West African Association, 68 Coleman Street, London, E.C
Brunner, Mond & Co., London.
Cadbury Bros., Bourneville, Birmingham.
Cargo Supervisors, Ltd., Liverpool.
Co-operative Wholesale Society, 1 Balloon Street, Manchester.
Craig & Co., Paisley, Scotland (Machinery).
Eastern Palm Estates, 38 Mark Lane, London, E.C.
Elder, Dempster & Co., 4 St. Mary Axe, London, E.C.
Frame & Co., Mincing Lane, London, E.C.
Fry, Messrs., Bristol.
Hartley & Moore, Ltd., 66 Victoria Street, London, S.W.
Hind & Lund, Preston (Machinery).
Les Huileries du Congo, Brussels.
Lever Bros., Port-Sunlight.
Lipton, Messrs., London.
Miller Bros., Liverpool.
New Ivory Coast Co., Ltd., 7/8 Great Winchester Street, London,
Palmine, Ltd., Moorgate Street House, London, E.C.
Rose Downs Thompson, Ltd., London and Hull.
Scott & Sons, Ltd., 72 Oxford Street, London, W.
Tin Areas of Nigeria, Giltspur Street, London, E.C.
Wray, Sanderson & Co., Hull